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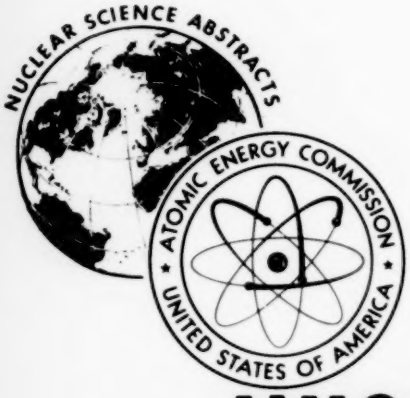


# NUCLEAR SCIENCE ABSTRACTS

Volume 17 Number 19

Abstracts 31793-33411

October 15, 1963

UNITED STATES ATOMIC ENERGY COMMISSION
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Volume 17, Number 19, October 15, 1963

# NUCLEAR SCIENCE ABSTRACTS

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# TABLE OF CONTENTS

Volume 17, Number 19, October 15, 1963


| Category | Page |
|---|---|
| GENERAL AND MISCELLANEOUS | 4239 |
| BIOLOGY AND MEDICINE | 4242 |
| General and Miscellaneous | 4242 |
| Biochemistry, Nutrition, and Toxicology | 4244 |
| Fallout and Ecology | 4245 |
| Radiation Effects on Living Tissues | 4246 |
| Radiation Sickness | 4263 |
| CHEMISTRY | 4267 |
| General and Miscellaneous | 4267 |
| Analytical Procedures | 4267 |
| Inorganic and Physical Chemistry | 4272 |
| Organic Chemistry | 4288 |
| Radiation Chemistry and Radiochemistry | 4289 |
| Raw Materials and Feed Materials | 4293 |
| Separation Processes | 4294 |
| ENGINEERING AND EQUIPMENT | 4297 |
| General and Miscellaneous | 4297 |
| Heat Transfer and Fluid Flow | 4301 |
| Materials Testing | 4304 |
| GEOLOGY, MINERALOGY, AND METEOROLOGY | 4306 |
| HEALTH AND SAFETY | 4310 |
| INDUSTRIAL APPLICATIONS OF ISOTOPES AND RADIATIONS | 4315 |
| INSTRUMENTS AND INSTRUMENTATION | 4317 |
| General and Miscellaneous | 4317 |
| Radiation Detection | 4324 |
| ISOTOPE SEPARATION | 4333 |
| MATHEMATICS AND COMPUTERS | 4334 |
| METALS, CERAMICS, AND OTHER MATERIALS | 4335 |
| General and Miscellaneous | 4335 |
| Corrosion | 4338 |
| Fabrication | 4338 |
| Properties and Structure | 4345 |
| Radiation Effects | 4357 |
| PHYSICS | 4364 |
| General and Miscellaneous | 4364 |
| Astrophysics, Cosmology, and Geophysics | 4382 |
| Cosmic Radiation | 4388 |
| Criticality Studies | 4389 |
| Elementary Particles and Radiations | 4390 |
| Neutron Physics | 4397 |
| Nuclear Properties and Reactions | 4399 |
| Particle Accelerators | 4414 |
| Plasma Physics and Thermonuclear Processes | 4418 |
| Shielding | 4431 |
| Theoretical Physics | 4431 |
| REACTOR TECHNOLOGY | 4434 |
| General and Miscellaneous | 4434 |
| Power Reactors | 4443 |
| Production Reactors | 4452 |
| Research Reactors | 4452 |
| SPACE APPLICATIONS AND TECHNOLOGY | 4455 |
| WASTE DISPOSAL AND PROCESSING | 4457 |
| CORPORATE AUTHOR INDEX | INDEX-1 |
| PERSONAL AUTHOR INDEX | INDEX-8 |
| SUBJECT INDEX | INDEX-41 |
| REPORT NUMBER INDEX | INDEX-104 |

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Volume 17, Number 19 October 15, 1963

# NUCLEAR SCIENCE ABSTRACTS

## GENERAL AND MISCELLANEOUS

**31793** (BNL-782) NUCLEAR ENGINEERING DEPARTMENT PROGRESS REPORT, SEPTEMBER 1–DECEMBER 31, 1962. Jean H. Reynolds, ed. (Brookhaven National Lab., Upton, N. Y.). Contract AT-30-2-GEN-16. 105p. (BNL-S-63)

Separate abstracts were prepared for sections on reactor physics, chemistry and chemical engineering, radiation, hot laboratories, metallurgy, and engineering. (D.C.W.)

**31794** (BNL-782(p.1-17)) REACTOR PHYSICS DIVISION. J. Chernick, H. Kouts, et al. (Brookhaven National Lab., Upton, N. Y.).

Developments in reactor systems, resonance physics, reactor kinetics, neutron thermalization, lattice studies, settled bed reactors, direct conversion, chemonuclear reactor studies, and organic reactor studies are reported. (D.C.W.)

**31795** (BNL-782(p.18-43)) CHEMISTRY AND CHEMICAL ENGINEERING DIVISION. O. E. Dwyer, R. H. Wiswall, et al. (Brookhaven National Lab., Upton, N. Y.).

The relative partial molar free energy of mixing NaCl in $CeCl_3$ was obtained as were the free energies of formation of $AlF_3$ and $ThF_4$. The dissolution of Mg in $MgCl_2$ was investigated, and a spectrophotometric study of Pb in molten $PbCl_2$ was undertaken. Perfluorocyclohexane was successfully purified by gas-liquid chromatography, and the synthesis of rare earth compounds by radiation was studied. Measurement of graphite surface area by Kr absorption was also examined. Production of the aziotrope NOF · 3.1HF was investigated, and the properties of the material as a solvent for $UO_2$ were evaluated. Volatilization of NOF-type substances ($NOUF_4$, etc.) was also examined, as were the fundamental aspects of corrosion in the Nitrofluor processing technique. Uranium was successfully removed from $UC_2$ using NOF · 3.1HF. Uranium extraction from Al–U alloy and stainless steel clad $UO_2$ by hydrochlorination and chlorination was carried out. Developments in waste disposal, mainly in phosphate glass formation, are described along with results of investigations of fission product release from fuel elements. Heat transfer to Hg and alkali metals flowing through rod bundles, concentric annuli, and eccentric annuli were also studied. (D.C.W.)

**31796** (BNL-782(p.44-50)) RADIATION DIVISION. B. Manowitz, D. Ballantine, et al. (Brookhaven National Lab., Upton, N. Y.).

The yields of radiolytic gas from irradiated solid solutions of acrylamide and propionamide were studied as well as the effect of O on the decay rate of the ESR spectrum of irradiated solid solutions. The dielectric loss in polymerizing systems is also being investigated. Radiation polymerization of $\alpha$-methylstyrene and radiolysis of toluene and xylene isomers were also examined. Ethylene was polymerized by irradiation in the presence of about 30 monomers. A 20 wt % $U^{235}$ in Pd alloy was developed for high temperature resistance in air streams. The absorption of photon energy in radiation sources of various shapes was calculated. Work on the solar cell dosimeter was completed, and the electrical discharge in irradiated shielding glass was studied. Clinoptilolite was used to remove Cs from wastes, while Linde AW500 molecular sieves removed both Cs and Sr. The constants for the formation of various iodide ions from iodine and iodide ions in nitrobenzene were determined. (D.C.W.)

**31797** (BNL-782(p.51-9)) HOT LABORATORY DIVISION. L. G. Stang, Jr., M. Hillman, et al. (Brookhaven National Lab., Upton, N. Y.).

Production of $Y^{87}$, $Cs^{132}$, $Se^{72}$, and high-specific activity $Mg^{24}$ were studied. The decay of the 0.175-Mev peak of $Sc^{48}$ was followed, and the half life of pure $Al^{28}$ was determined to be 2.238 ± 0.006 min. A technique for separating Co from Mn by ion exchange was perfected. Hydrolysis of Am was found to limit the pH range over which Am can be extracted by thenoyltrifluoroacetone. Waves at the dropping Hg electrode in molten $LiNO_3$–$KNO_3$ eutectic were analyzed, and a nondestructive quantitative $\gamma$-$\gamma$ spectrometric procedure for determining $Co^{60}$ in samples containing $Co^{58}$–$Co^{60}$–$Fe^{59}$ in the ratio 400 : 1 : 2 was developed. A vacuum chamber and solid-state detector for spectrometric study of neutron-charged particle reactions were assembled. Isotope production and liquid waste operations are summarized. (D.C.W.)

**31798** (BNL-782(p.60-91)) METALLURGY DIVISION. D. H. Gurinsky, A. Fleitman, et al. (Brookhaven National Lab., Upton, N. Y.).

The resistance of metals, notably refractory metals and carbon steel, to corrosion by boiling Hg and Na was investigated. Fuel elements from the HFBR, MTR, and ETR were examined, as were the alloy theory and nature of solids. Techniques for forming microcrystalline thin films by evaporation were studied. Neutron damage to Fe and other body-centered-cubic metals also received attention, as did the effects of radiation on the physical and structural properties of graphite. Diffusion in carbides and reactions of Br and I with graphite were also included in the study. A Re-graphite thermocouple was tested at 750 to 2230°C for 640 hr. Weld examinations and metallographic

studies of Sputnik-4 fragments and of Pb–Bi eutectic loops are also reported. (D.C.W.)

**31799** (BNL-782(p.92-4)) ENGINEERING DIVISION. T. V. Sheehan, R. Baldwin, et al. (Brookhaven National Lab., Upton, N. Y.).

Developments in the design, construction, or fabrication of the high flux beam reactor, metal heat transfer loops, the chemonuclear loop, test facilities, and other projects are summarized. (D.C.W.)

**31800** (NP-12981) UNITED KINGDOM ATOMIC ENERGY AUTHORITY NINTH ANNUAL REPORT FOR THE PERIOD APRIL 1, 1962–MARCH 31, 1963. (United Kingdom Atomic Energy Authority, London). 94p.

The ninth annual report of the United Kingdom Atomic Energy Authority contains information on research programs, membership, finance and accounts, production and processing plants, reactor development, nuclear weapons and test detection, health and safety, information services, commercial operations and raw materials, international relations, functions of authority establishments, and list of reactors. The research programs discussed pertain to chemistry, plasma physics, fusion physics, metallurgy, radiation effects, fuel development, nuclear chemistry, instrumentation, and various other programs related to atomic energy development. (N.W.R.)

**31801** (PNE-202F) SEDAN LONG RANGE BLAST PROPAGATION. Final Report. Jack W. Reed and Hugh W. Church (Sandia Corp., Albuquerque, N. Mex.). June 1963. Project PLOWSHARE. 35p.

Microbarograph records of air-blast waves from the Sedan shot 635 ft below the surface were made at eight stations in California and Nevada at ranges from 100 to 230 miles. A 1.2-ton high-explosion calibration shot was fired at Sedan minus 2 minutes to establish propagation conditions for bursts in air. Comparison of recorded signals indicated that Sedan blast-wave amplitudes averaged 20% of amplitudes which would have been transmitted had the Sedan yield been free-air burst. Individual transmissivity values ranged from 5 to 35%. Variations around the average were probably caused by atmospheric turbulence. Sedan blast waves were ducted toward the west by atmospheric refraction in the ozonosphere where strong summer easterlies were blowing at 100,000- to 200,000-foot altitudes. Rocket wind measurements were made at Tonopah Test Range. Rocket and rawinsonde data were used to calculate atmospheric blast propagations which are in fair agreement with microbarograph measurements. (auth)

**31802** (PNE-217F) MASS DISTRIBUTION AND THROWOUT STUDIES. R. H. Carlson and W. A. Roberts (Boeing Co., Seattle). May 1963. Project SEDAN. 146p.

Analysis of data on distribution of ejecta on the ground surrounding a nuclear crater collected at 117 sampling stations indicates that areal density varies inversely as distance raised to the 4.3 power. Circumferential variation in areal density was significant along all sampling rings; the ratio of highest observation to lowest was 37, 7, 10, and 32 at incremental distances in crater radii of 3.5, 4.7, 7, and 9.3 respectively. The total ejecta mass represented about 58% of the mass inferred from the apparent crater volume suggesting that about 37% of the crater volume was caused by compression of the surrounding desert alluvium. One half of the total mass of material ejected was deposited between the crater edge and two crater radii, whereas 97% of the total ejecta mass was deposited within ten crater radii. The ejecta profile exhibited a two-layer system, the lower layer consisting of the fine material ejected in mass or bulk. The upper layer consisted of larger particulate materials which were subjected to atmospheric influence when ejected along their ballistic trajectories. The missile-like material in the upper layer and the discrete masses of alluvium which reated hundreds of impact craters probably were deposited late in the time history of ejecta deposition. (auth)

**31803** (UCRL-7224(Rev.II)) THE PHENOMENOLOGY OF THE MASS MOTION OF A HIGH ALTITUDE NUCLEAR EXPLOSION. Stirling A. Colgate (California. Univ., Livermore. Lawrence Radiation Lab.). May 13, 1963. Contract W-7405-eng-48. 34p.

The persistence of the free expansion of the detonation products of a high-altitude detonation is determined by the sum of the stresses of the environment. Below 200 km the classical dynamic friction with the air couples the detonation products to a very much larger mass of air. Above this altitude more uncertain plasma phenomena of magnetic and electrostatic shocks must be considered to determine this coupling. If a cubic scale height of air is raised to a temperature such that its sound speed is greater than escape velocity, it jets upward, and the ionized fraction is stopped and mixed unstably with the earth's magnetic field. The subsequent expansion along the field lines deposits the major fraction of the debris at the opposite conjugate point. The $\beta$ decay in transit on the various L surfaces reached by unstable mixing determines the high energy electron injection into trapped orbits. For the Starfish event (1.4 megatons at 400 km) theory predicts that the detonation products and a cubic scale height of air expands upward until stopped by the earth's field at 1000 km. In addition the deposition of the debris in the atmosphere is expected at the southern conjugate point at 250 km altitude dispersed over 300 km due to magnetic field mixing. Approximately 5% $\beta$ injection into trapped orbits of $L > 1.3$ is expected. (auth)

**31804** (WT-1462) PROTECTION AGAINST FALLOUT RADIATION IN A SIMPLE STRUCTURE. A. J. Breslin, P. Loysen, and M. S. Weinstein ([New York Operations Office. Health and Safety Lab., AEC]). [1962]. Project 32.1 [of] Operation PLUMBBOB. 64p.

A reinforced Butler building was exposed to fallout from Shots Diablo and Shasta, and the resulting dose rates and fallout deposition inside and outside the structure were measured with various instruments and techniques. Protection factors and roof and ground contributions to the total dose rates at points within the structure were determined from the measurements. Comparisons were made with the results of theoretical and other experimental studies. Information obtained from this experiment should be of value as basic experimental data for fallout protection work, although it is recommended that additional substantiative data be obtained under more controlled conditions. (auth)

**31805** COORDINATED DESIGN OF RADIOISOTOPE LABORATORIES. Chih H. Wang (Oregon State Univ., Corvallis), R. A. Adams, and Wyman K. Bear. Atomlight, No. 30, 1-10(July 1963).

The design of a laboratory especially for the applications of radioisotopes is described. Floor arrangement, ventilation and heating, electrical utilities, sewage disposal, radioactive waste disposal, laboratory fixtures, and radiochemical hoods are discussed. (P.C.H.)

**31806** PROCEEDINGS OF THE FOURTH CELLULOSE CONFERENCE HELD AT SYRACUSE, NEW YORK,

OCTOBER 18–19, 1962. R. H. Marchessault, ed. J. Polymer Sci., Pt. C, No. 2, 1-548(1963).

Forty-two papers are included: 3 were abstracted for NSA, and the remaining did not pertain to nuclear science. The papers not abstracted include information on properties of cellulose polymers and co-polymers, molecular architecture of wood, future trends in cellulose research, decomposition, polymerization, grafting, and structure of cellulose. (P.C.H.)

**31807** RADIATION-INDUCED GRAFT POLYMERIZATION OF STYRENE IN WOOD. K. V. Ramalingam, G. N. Werezak, and J. W. Hodgins (McMaster Univ., Hamilton, Ont.). J. Polymer Sci., Pt. C, No. 2, 153-67(1963).

Polystyrene grafting to cellulose in red pine sapwood was accomplished by $\gamma$ irradiation of the ternary solution of styrene, methanol, and $H_2O$. The resulting material possesses substantially enhanced bending strength and dimensional stability. Optimum conditions were determined by a factorial experimental design. Electron spin resonance studies revealed two distinct types of long-lived free radicals, one of which is the specific precursor for the grafting reaction. (auth)

**31808** GRAFTING POLYMERS ONTO CELLULOSE BY HIGH-ENERGY RADIATION. II. EFFECT OF SWELLING AGENTS ON THE GAMMA-RAY INDUCED DIRECT RADIATION GRAFTING OF STYRENE ONTO CELLULOSE. R. Y.-M. Huang and W. H. Rapson (Univ. of Toronto). J. Polymer Sci., Pt. C, No. 2, 169-88(1963).

The direct radiation graft copolymerization of styrene onto cotton cellulose and rayon by $\gamma$ irradiation from a $Co^{60}$ source at a high dose rate of 1.4 Mrads/hr was investigated. The grafting was carried out in air at radiation doses in the range of 0 to 8 Mrads. Varying amounts of grafting of up to several hundred per cent were obtained by controlling reaction variables of cellulose preswelling, total radiation dose, and styrene-solvent composition. No grafting was obtained when unconditioned cellulose was irradiated in bulk styrene. Grafting occurred readily, however, when the cellulose was first preswollen with a polar swelling agent such as water, formamide, formic acid, or dimethyl sulfoxide, then placed in bulk styrene or styrene-solvent solution and irradiated. The effect of water in the radiation grafting was investigated. In bulk styrene, for a given radiation dose, grafting was found to depend on the water content of the preswollen cellulose. For rayon, grafting increased sharply after 30% water content in rayon, passed through a maximum at 60 to 80%, and then decreased again. For cotton cellulose, grafting occurred after 10% water content, increased up to approximately 20%, and then remained constant. Efficiency of grafting was found to decrease with increasing per cent grafting and radiation dose. The effect of solvent additives such as methanol, ethanol, and acetic acid on the grafting was also studied. Strength properties, microphotographs of grafting cross sections, and the infrared spectra of rayon-polystyrene graft copolymers are presented. (P.C.H.)

**31809** PREPARATION AND CHARACTERIZATION OF SOME CELLULOSE GRAFT COPOLYMERS. PART I. H. Yasuda, J. A. Wray, and V. Stannett (Syracuse Univ., N. Y.). J. Polymer Sci., Pt. C, No. 2, 387-402(1963).

Graft copolymers prepared by use of the ceric ion, uv light, mutual radiation, and preirradiation methods were: cellulose–acrylamide; cellulose acetate–styrene; and cellulose acetate–methyl methacrylate. Fractional precipitation and extraction methods were developed to show proof of grafting and to estimate the efficiency of the grafting process. It was shown that only a small proportion of the cellulosic chains participated in the grafting reaction under heterogeneous conditions. On the other hand, the vinyl polymer was present from 30 to nearly 100% in grafted form. The cellulose acetate–styrene graft copolymer was isolated from the homopolymers by a fractional extraction technique and the molecular weight of the side chain determined after hydrolysis of the cellulose backbone. In general, grafts consisted of very long polystyrene side chains attached to comparatively short cellulose acetate backbone chains. The solubility behavior of such grafts was shown to be quite different from that of the corresponding physical mixtures. The graft polymers were less soluble than either of the homopolymers alone. The graft polymer was found to tolerate less cellulose acetate in a mutual solvent than the polystyrene itself. (auth)

**31810** COMPLETE BIBLIOGRAPHY OF THE PUBLICATIONS ISSUED BY THE INSTITUTE OF NUCLEAR RESEARCH OF THE HUNGARIAN ACADEMY OF SCIENCES (DEBRECEN, HUNGARY) UP TO DECEMBER 31st, 1962. Magy. Tud. Akad. At. Kut. Int. (Debrecen), Kozlemen., 5: Suppl. to No. 2, 1-71(July 1963).

References (317) are given to journals and theses published from 1948 to December 1962. Topics covered include: nuclear reactions; nuclear spectroscopy and investigation of $\beta$ interactions; radioactivity in nature and geochemistry of U and its fission products; neutron physics; medical and biological applications of radioisotopes; analytical and radiochemistry; electronics, vacuum techniques, and instrumentation. An author index is included. (P.C.H.)

**31811** NUCLEAR POWER RESEARCH IN RUMANIA. Florian Ciorascu. Pokroky Mat., Fys. Astron., 8: 170-2 (1963).

Research in Rumania is concentrated mainly at the Institute for Atomic Physics. It is equipped with a 2000-kw reactor, a 6-Mev cyclotron, and a 25-Mev bevatron. The Institute has units for the study of nuclear physics, nuclear electronics, radiochemistry, cosmic rays, and physics of elementary particles. Some special fields of research are described. Lately, emphasis was placed on the discovery of new organic moderators from Rumanian crude oil, and on the production of nuclear graphite from pure soot. Almost 40 radioisotopes are produced, including several hundred compounds with radioactive atoms. New instruments are designed for the application of radioisotopes. (OTS)

**31812** FLUX TO DOSE RATE CONVERSION FACTORS FOR GAMMA RAY EXPOSURE. Joseph H. Smith (California Inst. of Tech., Pasadena). 7p. (CONF-46-63)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Conversion factors are presented in graphical form for the convenient calculation of gamma-ray field strength in terms of the recommended units of exposure dose: ergs per gram, referenced to carbon. (auth)

# BIOLOGY AND MEDICINE

## General and Miscellaneous

*Refer also to abstract 32402.*

**31813** (AERE-R-4309) THE DETERMINATION OF INORGANIC ELEMENTS IN BIOLOGICAL TISSUE BY ACTIVATION ANALYSIS. H. J. M. Bowen and P. A. Cawse (United Kingdom Atomic Energy Authority. Research Group. Wantage Research Lab., Wantage, Berks, England). May 1963. 42p.

This paper gives practical details of methods employing neutron activation which have been used for determining the amounts of a number of elements found in biological tissue. The elements discussed include barium, bromine, calcium, chlorine, copper, gallium, iodine, magnesium, manganese, molybdenum, phosphorus, potassium, ruthenium, selenium, sodium, strontium, tungsten, vanadium, and zinc. (auth)

**31814** (KFK-143) DAS RADIOGOLD (Au-198) IN DER MEDIZIN. EINE LITERATURUBERICHT 1958-1962. (Radiogold (Au-198) in Medicine. A Literature Search 1958-1962). Volker Schneider (Kernforschungszentrum, Karlsruhe, Germany). May 1963. 26p.

References on the use of radiogold in medicine are presented alphabetically by author under the following topics: review publications, pleura and peritoneal cavities, bladder, colon carcinoma, prostates, lungs, leukemia, bone marrow, lymph nodes and system, liver, distribution, pancreas, other organs, gold seeding of hypophysis, gold seeding of other organs or glands, techniques, preparation, silver-coated gold colloids, and gold-carbon suspension. Two-hundred-and-sixty-eight references are included. (M.C.G.)

**31815** (LADC-5627) ELECTRONIC PROCESSING AND ANALYSIS OF METABOLIC DATA. C. R. Richmond, J. E. Furchner, P. N. Dean, and P. McWilliams (Los Alamos Scientific Lab., N. Mex.). [1963]. Contract W-7405-eng-36. 44p. (CONF-67-17)

From Health Physics Society Annual Meeting, New York, June 1963.

A complete system is described for electronically processing and analyzing metabolic data which are used to estimate radiation protection guides for man. Counting data for multichannel liquid scintillation detectors, together with experimental information which is manually dialed into the punch control unit of the counter, are automatically punched onto paper tape or IBM data cards. The cards comprise the input for a computer program (RTW) which will calculate elapsed time between radionuclide administration and time of measurement, correct all data for changes in counting efficiency relative to measurements made on standards at zero time and for physical decay, if desired, and express the observed counting information as effective or biological retention at any time after the initial measurement. Portions of the RTW program output are on IBM data cards in a format compatible with the input requirements for a least squares computing method programmed for the IBM 7090 which, in turn, will derive the parameters of the function which best fit the data. Lastly, a General-Dynamics Model SC-4020 tape-to-film device is used to produce on 35-mm film a plot of the observed retention data, the fitted curve, and ancillary labeling statements. (auth)

**31816** (ORO-605) SEMI-ANNUAL PROGRESS REPORT [ON AGRICULTURAL RESEARCH], JULY 1–DECEMBER 31, 1962. (Tennessee. Univ., Oak Ridge. UT-AEC Agricultural Research Lab.). Contract AT-40-1-GEN-242. 130p.

The status of burros, swine, and cattle surviving irradiation from nuclear explosions and critical assemblies is reported. Emphasis is placed on the effects of irradiation on the central nervous system. Data are presented from studies on: the effects of radiation on reproduction in cattle, sheep, and rabbits; physiological effects of radiation in sheep and rats; tracer studies on the metabolism of Ca, Sr, Zn, I, Se, and Rb in domestic animals; an investigation of methods for the removal of $Cs^{134}$ from beef; the metabolism of fission products in poultry; the chemistry of fission products in soil; and factors affecting the radiosensitivity of seeds and other plant parts that can be used by plant breeders to increase the variability of their foundation stocks. (C.H.)

**31817** (TID-19122) RELATIONSHIPS BETWEEN MARINE INVERTEBRATE IN FAUNA DISTRIBUTION AND SEDIMENT TYPE DISTRIBUTION IN BOGUE SOUND, NORTH CAROLINA. Final Report. Charles Everett Brett (North Carolina. Univ., Chapel Hill). [nd]. Contract AT(40-1)-2593. 211p.

Hydrographic, sedimentary, and faunal data are collected periodically from Sept. 1959 through Jan. 1962 at 39 stations along 5 transects of Bogue Sound, North Carolina. All animals studied live within the bottom sediments except Aequipecten irradians (Lamarck). It was concluded that if radioactive materials are introduced into the Bogue Sound area, the greatest concentration by uptake in bottom sediments will occur where commercial shellfish are most concentrated. (C.H.)

**31818** (TID-19168) MEASUREMENT OF CARDIO-PULMONARY BLOOD VOLUMES BY MEANS OF QUANTITATIVE RADIOCARDIOGRAPHY. L. Donato (Pisa, Italy. Universita. Centro di Medicina Nucleare). [1962]. Contract AT(30-1)-2648. 18p.

Radiocardiography is aimed at obtaining indicator dilution curves by injecting $\gamma$-emitting indicators and recording the curve with a scintillation counter collimated over the precordium. The traditional cardiography technique involves the taking of many blood samples after injection of a colored dye. Results obtained by the two methods are discussed with emphasis on the measurement of circulatory blood volumes. Results obtained in normal individuals and in subjects with pulmonary emphysema and chronic cardiopulmonary obstruction are compared. Analog computers were used to analyze double peaked cardiocardiography curves obtained by the injection of $I^{131}$-labeled serum albumin into the right atrium. (C.H.)

**31819** (TID-19173) STUDY OF THE HEMODYNAMIC CHARACTERISTICS OF THE PULMONARY CIRCULATION AND THE LEFT HEART BY MEANS OF RADIOCARDIOGRAPHY. Annual Progress Report. Gabriele Monasterio and Luigi Donato (Pisa, Italy. Universita. Centro di Medicina Nucleare). July 20, 1963. Contract AT(30-1)-2648. 18p.

Progress is reported in the development of a radiocardiographic technique into a quantitative method for the study of cardiopulmonary circulation in man in health and

disease. Analog computer analysis was applied in interpreting radiocardiographic data from a twin counter system. (C.H.)

**31820** (UR-630) PARTICIPATION OF THE COAGULATION MECHANISM IN TUMOR LOCALIZATION OF $I^{131}$-LABELLED FIBRINOGEN. Joseph R. Shaeffer (Rochester, N. Y. Univ. Atomic Energy Project). June 20, 1963. Contract W-7405-eng-49. 45p.

A transplantable tumor of the rat, the Murphy-Sturm lymphosarcoma, was found to contain 15 to 25% of the administered radioactive dose 18 hours after intravenous injection of $I^{131}$-labeled rat fibrinogen in a rat bearing a tumor in the 2 to 12 gm weight range. At this time the concentration of radioactivity per gm of tumor was found to be some 4 to 15 times that of such vascular organs as the liver and kidney, smaller tumors (2 to 5 gm) localizing much more of the injected radioactive dose per gm than larger tumors (8 to 12 gm). These tumors did not concentrate radioactivity after intravenous injection of either $I^{131}$ γ-globulin or inorganic $NaI^{131}$. The administration of heparin or warfarin in dosages adequate to completely inhibit the blood coagulation mechanism throughout the 18-hour experimental period decreased this specific tumor localization of $I^{131}$ fibrinogen by 60 to 80%. It is concluded that the coagulation mechanism participates in the localization of $I^{131}$ fibrinogen in the Murphy-Sturm lymphosarcoma. Physiological mechanisms of action other than the anticoagulative one which could possibly explain the effect of heparin and warfarin on tumor localization are discussed. No experimental evidence for an enhancement of fibrinolysis as the mechanism of tumor $I^{131}$ localization decrease by the drugs was found. In particular, these anticoagulants did not decrease whole-body radioactivity retention, and the radioactivity retained in the tumor-bearing rats receiving anticoagulant was highly clottable 18 hours after injection of $I^{131}$ fibrinogen. (auth)

**31821** SUPPRESSOR MUTATIONS FOR THE ISOLEUCINE LOCUS IN SACCHAROMYCES. Satya N. Kakar (Univ. of Washington, Seattle). Genetics, 48: 967-79(Aug. 1963).

It was shown that a large number of isoleucine revertants result from suppressor mutation. Three types of suppressors of isoleucine requirements have been encountered. One kind of suppressor specifically suppresses the allele $is_{1-1}$ and none of the other three alleles. The second type is nonspecific and suppresses all of the alleles. Both of these kinds of suppressors are dominant. Whereas mutation at any one of the five loci indicated can give rise to specific suppressors, all of the four nonspecific suppressors analyzed are the result of mutation at a single locus. The third type of suppressor, which is also nonspecific, permits the utilization of threonine as a substitute for the isoleucine requirement for growth. This property seems to be under the control of two recessive but complementary, linked genes. Growth studies indicate that the presence of specific suppressor ($S_1$-$is_{1-1}$) in a haploid culture with any one of the isoleucine alleles ($is_{1-1}$, $is_{1-2}$ or IS) stimulates the growth to some extent. There is also some evidence, although not conclusive, that in some cases a haploid strain possessing two suppressor genes gives poor growth. It is suggested that the nonspecific suppressors act by making available an alternative pathway of synthesis for isoleucine, and that the specific suppressors act by repairing the primary defect in some way or by controlling some environmental factor. (auth)

**31822** CURRENT APPLICATIONS OF FIBER OPTICS TO FLUOROSCOPY. H. P. Hovnanian, P. B. Brand, T. A. Brennan, and E. Watkins, Jr. (Avco Mfg. Corp., Wilmington, Mass.). Med. Electron. Biol. Eng., 1: No. 1, 71-4 (Jan.-Mar. 1963).

It is only during the past few years that optic glass fibers became available for practical usage. Their potential in medical diagnosis is becoming increasingly apparent. The description is aimed at roentgen fluoroscopy from hitherto inaccessible small areas. The principles involved include an image-converting receiver at the distal end of a mechanically flexible optic fiber bundle. The latter conducts the converted image to a removed detector such as the eye, a television camera or an image amplifier. Calculations also show that x irradiation can be substantially reduced by using this method. (auth)

**31823** NEW ACCESSORIES FOR PRECISE TELETHERAPY WITH COBALT-60 UNITS. Basil S. Proimos. Radiology, 81: 307-16(Aug. 1963).

In the interest of more precise $Co^{60}$ radiotherapy, the author describes a device for reducing effective source size, equipment for the protection of the spinal cord and eyes in rotational therapy, a method for synchronous field shaping in rotational therapy, a technique for stationary field shaping, and the construction of a phantom of changeable cross section. (H.M.G.)

**31824** SOME PROBLEMS PECULIAR TO ELECTRON THERAPY. J. E. Morgan and Andrew H. Dowdy (Univ. of California, Los Angeles). Radiology, 81: 317-19(Aug. 1963).

Some significant aspects of electron-beam propagation and scattering phenomena are discussed, with particular reference to shielding requirements as differentiated from those usually encountered in x-ray work. Development of a technique for utilizing a wide-angle electron beam at long distance for total skin therapy is reported, together with alternative solutions to the special problem of eye protection for the patient undergoing such therapy. Dosimetric data from phantom measurements are tabulated to compare the relative merits of various eye-shielding arrangements. (auth)

**31825** THE THERAPEUTIC EFFECT OF RADIOACTIVE PHOSPHORUS ON CERTAIN FORMS OF LEUCOSIS IN POULTRY. J. Gligorijevic, C. Rusov, and B. Djukic (Inst. for the Application of Nuclear Energy in Agriculture, Veterinary Medicine, and Forestry, Belgrad). Vet. Glasnik, 17: 483-9(1963).

Experiments showed that a single application of radioactive $P^{32}$ with a dosage of 300 μC/kg in poultry affected by erythroleukosis and lymphomatosis caused clinical and hematological remission. A pathomorphological study showed that there had been a certain abatement of the process, accompanied by multiplication of the unspecific connective tissue. (OTS)

**31826** STRAHLENFORSCHUNG UND STRAHLENBEHANDLUNG. VORTRAGE AUS DEN GEBIETEN DER STRAHLENPHYSIK, STRAHLENBIOLOGIE UND STRAHLENTHERAPIE. BAND III. 42. TAGUNG DER DEUTSCHEN RONTGENGESELLSCHAFT IN HAMBURG VOM 16. BIS 19. APRIL 1961. (Radiation Research and Radiation Treatment. Reports from the Area of Radiophysics, Radiobiology, and Radiotherapy. Volume III. 42nd Session of the Deutsche Rontgengesellschaft in Hamburg from April 16 to 19, 1961). Hans Meyer and Josef Becker. Munich, Verlag Von Urban and Schwarzenberg, 1962. 273p.

Thirty papers are included on isotopes in paleontological studies, radiological diagnosis, and therapy of thyroid disorders; radiosensitivity of tumors; clinology and methodology of radiotherapy; radiation dosimetry; radiobiology;

radioprotection; and medical liability in radiotherapy and diagnosis. (J.S.R.)

**31827** LIFE-SPAN SHORTENING FROM VARIOUS TISSUE INSULTS. H. J. Curtis and Cathryn Crowley (Brookhaven National Lab., Upton, N. Y.). p.267-71 of "Cellular Basis and Aetiology of Late Somatic Effects of Ionizing Radiations." New York, Academic Press, 1962. (BNL-6037)

From experiments in mice, it is shown that a specific organ stress, mercury poisoning of the kidney, can cause irreparable damage which persists indefinitely. The animal is able to compensate for this damage when it is young, but as it ages it fails to compensate and death follows. Tissue scarring is apparently one of the important factors in the ageing process. (auth)

**31828** THE USE OF RADIOACTIVE ISOTOPES IN SURGERY. J. Mueller. Thesis, Dresden, Medizinische Akademie, 1962. 136p. $2.00.

Irradiation methods, both general and selective, are discussed. The use of isotopes for the treatment of hyperthyreosis is described in detail. (Gmelin Inst.)

**31829** INVESTIGATIONS OF ENVIRONMENTAL RADIATION AND ITS VARIABILITY. W. Herbst (Universitat, Freiburg i. B.). 24p. (CONF-16-8)

From International Symposium on the Natural Radiation Environment, Houston, Tex., Apr. 1963.

Surveys of environmental background radiation were made. Studies were confined to measurements of the dose of exterior penetrating radiation and to coordination of these doses with population distribution. Special attention was given to the variability of this background radiation in dependence on the different natural conditions and those brought about by civilization factors. The geological variability of Switzerland presented an opportunity to study the connections between terrestrial radiation dose and geological structure These measurements were supplemented by corresponding measurements in the Federal Republic of Germany. Of the causes responsible for the variability of the background due to civilization factors, the influence of mining, road building, housing conditions, agriculture, forestry, and fallout from nuclear weapons were studied. It is considered that an exact picture of the radiation environment and of the radiation burden of man can be obtained only by considerations in the light of variability and diversity of radiation background. (auth)

## Biochemistry, Nutrition, and Toxicology

**31830** (TID-19127) BIOLOGICAL IMPLICATIONS OF ACCUMULATION OF ORGANIC MATERIALS BY SEDIMENTARY PARTICLES IN THE SEA. Final Report. (Texas. Agricultural and Mechanical Coll., College Station). Apr. 1961. Contract AT(40-1)-2061. 58p.

Progress is reported in an investigation on the effect of clay-mineral particles on the fate of radionuclides introduced into the sea. Results are presented from tracer studies on the ability of bacteria and various benthic animals to strip sorbed materials from mineral particles. It was shown that bacteria can hasten the leaching of certain sorbed materials from mineral particles and that bacteria increase diffusion of radionuclides from marine sediments. Both $Cs^{137}$ and $Ca^{45}$ were concentrated by algae and various benthic animals. The addition of clean clay to a contaminated marine environment did not demonstrably change the uptake of radionuclides. (C.H.)

**31831** (JPRS-19626) EFFECT OF MICROQUANTITIES OF STABLE STRONTIUM ON MINERAL METABOLISM AND UPTAKE OF $Sr^{90}$. V. A. Knizhnikov and P. F. Bugryshev. Translated from Gigiena i Sanit., 28: No. 2, 19-25 (1963). 14p.

The effects of long-term consumption of water with a high stable Sr content on the uptake of $Sr^{90}$ and $Ca^{45}$ by the rat skeleton after oral ingestion in minute quanitites was studied. The results show that the consumption of drinking water with a high stable Sr content led to a reduction in the accumulation of $Sr^{90}$ as well as $Ca^{45}$ in the skeleton. In rats fed drinking water with 15 mg/l of stable Sr per os for a prolonged period, the $Sr^{90}$ and $Ca^{45}$ content in the skeleton became less in experimental animals than in controls. The most striking circumstance in attempting to explain the mechanism of the effect of stable Sr is the fact that it induced a consistent reduction in the accumulation not only of $Sr^{90}$ but of $Ca^{45}$. It was concluded that the effect of the stable Sr cannot be explained as dilution or competition with Ca. (P.C.H.)

**31832** ON THE NATURE OF A DEOXYNUCLEOTIDE POLYMERASE-DEOXYRIBONUCLEIC ACID COMPLEX. Daniel Billen (Univ. of Texas, Austin and Anderson Hospital and Tumor Inst., Houston, Tex.). Biochim. Biophys. Acta, 68: 342-53(Mar. 26, 1963). (In English)

A deoxyribonucleotide polymerase–DNA complex, found in extracts of Escherichia coli strain 15 T-A-U-, was investigated. While all of the measurable polymerase is found associated with DNA following centrifugation in a sucrose gradient, only variable quantities of the enzymes required for phosphorylation of thymidine or the deoxynucleotide monophosphates were observed to be associated with the complex. Ribosomal contamination is a complicating factor. Obtaining extracts by the pressure cell method results in a change in the distribution pattern of the complex following centrifugation as compared to the extracts obtained by alumina grinding. The association of polymerase with DNA was found to be similar in extracts from cells showing extremes of DNA-synthesizing ability in vivo, x ray exposure of the cells prior to cell disruption did not measurably affect the polymerase–DNA relationship. E. coli polymerase will complex with either calf-thymus or bacterial DNA upon mixing and will show a sedimentation pattern in a sucrose gradient similar to that of the complex found in cell extracts. (auth)

**31833** THE MECHANISM OF ACTION OF ANTIRADIATION AGENTS. V. I. Kuznetsov and M. S. Kushakovskii (Kirov Military-Medical Academy of Order of Lenin, USSR). Med. Radiol., 8: No. 6, 27-32(June 1963). (In Russian)

Investigations were made on the influence of cystamine hydrochloride and S, beta-aminoethylisothiuronium hydrobromide on the oxygen balance in the human organism. Cystamine in peroral doses of 200–600 mg causes a rise of the basal metabolism, increased oxygen consumption in the lungs, intensified respiration of erythrocytes (in the presence of glucose), and reduction of methemoglobin. S, beta-aminoethylisothiuronium in similar doses causes a drop of the basal metabolism and a diminution of the coefficient of oxygen consumption in the lungs. S,-beta-aminoethylisothiuronium, in contrast to cystamine, penetrates the erythrocyte membrane but weakly. A supposition is made on the diverse mechanisms of antiradiation effect of the preparations. (auth)

**31834** ANOTHER VARIABLE TO BE OBSERVED IN AUTORADIOGRAPHS. R. T. Sims (Cambridge Univ., Eng.). Nature, 199: 395(July 27, 1963).

An experiment is presented to illustrate the use of radioautography to show that regions of a tissue have incorporated a tracer in a different way at the same time interval after its administration. Observations were made on the incorporation of tyrosine into the growing hair of rats. It is speculated that on suitable material it may be possible to demonstrate changes in the same region at different time intervals by the method. (P.C.H.)

**31835** ABSORPTION OF $Sr^{90}SO_4$ FROM THE LUNG. W. J. Bair and G. D. Smith (General Electric Co., Richland, Wash.). Proc. Soc. Exptl. Biol. Med., 113: 16-17 (May 1963). (HW-SA-2878)

The role of the lung in affecting the translocation of inhaled $Sr^{90}SO_4$ was evaluated by exposing a dog to a $Sr^{90}SO_4$ aerosol through a tracheal fistula. About one-half of the $Sr-Y^{90}$ deposited was rapidly translocated to the bone, and only 2% was retained in the lung one week after exposure. Fifteen per cent was cleared via the trachea, probably by the ciliary processes. (auth)

**31836** INFLUENCE OF DIETARY POTASSIUM AND SODIUM ON CESIUM-137 RETENTION IN RATS. R. H. Wasserman, C. L. Comar, and D. N. Tapper (Cornell Univ., Ithaca, N. Y.). Proc. Soc. Exptl. Biol. Med., 113: 305-7(June 1963).

The effect of supplementation of diet with high levels of KCl and NaCl on $Cs^{137}$ retention in rats was studied; the level of added alkali metal ion in each case was 5%. Both $Na^+$ and $K^+$ increased the rate of excretion of $Cs^{137}$ but also considerably enhanced water consumption. The response was probably due to the diuretic action of the salts rather than to specific ion antagonism. The exposure dose to the animal from $Cs^{137}$ was reduced by a factor of about 0.7 by high salt ($Na^+$ or $K^+$) intake. (auth)

**31837** EFFECTS OF DEUTERIUM OXIDE UPON PLAQUE FORMATION AND REPLICATION OF SIMIAN $VIRUS_{40}$. Richard I. Carp, Ivan Chudnow, Hilary Koprowski, and David Kritchevsky (Wistar Inst. of Anatomy and Biology, Philadelphia). Proc. Soc. Exptl. Biol. Med., 113: 569-71(July 1963).

The influence of $D_2O$ (25 to 50%) upon multiplication of and plaque formation by Simian $Virus_{40}$ was studied in Grivet monkey kidney tissue at 37°C and 40°C. At both temperatures presence of 25-50% of $D_2O$ in the growth medium results in reduced virus yield, lower endpoint titer and reduced plaque size. The effect is not due to inactivation of the virus by deuterium oxide. (auth)

**31838** SOME BIOCHEMICAL DISTURBANCES CAUSED BY IONIZING RADIATION IN AN ANIMAL ORGANISM IN RELATION TO ITS CONDITION OF NUTRITION. A. A. Shmidt. Tr. Inst. Eksperim. i Klinich. Med., Akad. Nauk Latv. SSR, No. 28, 79-82(1962).

One group of rats was fed white sugar and 26% protein-vitamin concentrate, while another group received sugar only. Some rats of each group were subjected to 700 r $\gamma$ rays from $Co^{60}$. A short summary of the results is presented. It was concluded that disturbances in metabolic processes occurring in animals under the effect of $\gamma$ irradiation show a definite ratio to the nutritional condition of the animals. (TCO)

**31839** FACTORS INFLUENCING THE BIOLOGICAL AVAILABILITY OF RADIONUCLIDES FOR ANIMALS AND MAN. C. L. Comar (Cornell Univ., Ithaca, N. Y.). 3p. (CONF-65-2)

From Federation of American Societies for Experimental Biology Meeting, Atlantic City, N. J., Apr. 1963.

Factors that govern the biological availability of $I^{131}$ and $Sr^{90}$ from fallout for the human population are reviewed. It is pointed out that fresh milk is the most important contributor of $Sr^{90}$ and $I^{131}$ to the human diet. Suggestions are presented for modifying feeding practices of cattle to reduce the levels of $I^{131}$ and $Sr^{90}$ in milk. (C.H.)

**31840** FACTORS INFLUENCING THE BIOLOGICAL AVAILABILITY OF RADIONUCLIDES FOR PLANTS. Ronald G. Menzel (Dept. of Agriculture, Beltsville, Md.). 15p. (CONF-65-4)

From Federation of American Societies for Experimental Biology Meeting, Atlantic City, N. J., Apr. 1963.

Plants are the major vector in the transfer of fallout radionuclide contamination from the environment to man. Three pathways of radionuclide contamination of plants are considered. Emphasis is placed on the uptake of $Cs^{137}$ and $Sr^{90}$ by food crops. (C.H.)

**31841** BONE CALCIUM AND STRONTIUM DISCRIMINATION. L. Singer and W. D. Armstrong (Univ. of Minnesota, Minneapolis). 7p. (CONF-65-5)

From Federation of American Societies for Experimental Biology Meeting, Atlantic City, N. J., Apr. 1963.

The effect of the fluoride content of the skeleton on the deposition of $Sr^{85}$ and $Ca^{45}$ in calcified tissues was investigated in rats and in samples of fat-free or ashed bone. Results indicate that the fluoride parameters investigated did not influence the ratio of $Ca^{45}/Sr^{85}$ deposition in bone. (C.H.)

**31842** SYNTHESIS OF $H^3$-LABELED AMINO ACIDS WITH HIGH SPECIFIC ACTIVITY AND THEIR APPLICATION FOR HISTOAUTORADIOGRAPHY. K. Hempel. Thesis, Cologne, Universität, 1962. 100p. $2.00.

New methods for synthesis of tritium-labeled amino acids with high specific activity (1000 mc/m mole and above) are described. Changes in tritium-labeled amino acids during storage are studied. An absorbed $\beta$ energy of $10^5$ rad results in radiochemical disintegration of 1.5%. Autoradiographic studies were made with several amino acids. It was demonstrated that protein production is 2 to 3 times higher in butter-yellow tumors than in liver tissue. Synthesis of melanine was studied in vivo with melanine-producing tumors. (Gmelin Inst.)

## Fallout and Ecology

**31843** THE $\beta$ RADIOACTIVITY OF THE ZOOPLANKTON OF THE BLACK SEA. M. Oncescu and O. Serbanescu (Inst. of Atomic Physics, Bucharest). Acad. Rep. Populare Romine, Studii Cercetari Fiz., 14: 133-41(1963). (In Rumanian)

The measurements of the $\beta$ activity, made immediately after the samples are collected, show a relatively intense radioactivity of the zooplankton of the Black Sea. As the $\beta$ activity decreases to a great extent after several months, the presence of radioisotopes with short life is assumed. The measurements were made on mixtures of zooplankton animals, and it was not possible to draw any conclusions on the distribution of activity in the various species or groups of animals. (tr-auth)

**31844** ATMOSPHERIC CONTAMINATION BY ARTIFICIAL RADIOACTIVE SUBSTANCES OVER THE ATLANTIC OCEAN IN 1961. V. N. Lavrenchik, L. N. Samoilov, P. M. Chulkov, V. F. Gorbunov, and N. S. Vel'tishcheva. At. Energ. (USSR), 14: 569-72(June 1963). (In Russian)

The geographical distribution of fission products (and $Be^7$) in the atmosphere over the Atlantic Ocean from 50° north latitude to 30° south latitude was measured on board the "Mikhail Lomonosov" from March 8th to July 2nd, 1961. The filtered air samples were ashed at 500°C, and the beta activity was measured on an end-window or cylindrical counter. All samples were subjected to a gamma scan on a NaI(Tl) scintillation counter having a 9% resolution for the 661 kev $Ba^{137}$ peak. A total of 30% of the 116 samples was analyzed radiochemically for $Ce^{144}$, $Be^7$, and $Sr^{90}$. The maximum concentration of $Ce^{144}$ is observed at 20 to 30° north latitude and 25 to 30° south latitude. The subtropical high pressure belts played an important role in carrying down contamination from the stratosphere. The average ratio of contamination in the northern hemisphere to that in the southern hemisphere was equal to ~4. This fact indicated that stratospheric mixing of air is slight in both hemispheres. A comparison of the average concentrations of $Ce^{144}$ in 1958 and 1961 indicated that the residence time of $Ce^{144}$ in the atmosphere is about one year for equatorial ejection. The concentration of $Ce^{144}$ over the ocean was at least twice that of $Ce^{144}$ over seas surrounded by large land masses. The concentration of $Be^7$ in the equatorial zone was relatively high due to the fact that in this region, ~70% of the $Be^7$ originates in the troposphere. (TTT)

**31845** GROSS BETA RADIOACTIVITY OF PLANKTON SAMPLES COLLECTED IN THE ADRIATIC AND LIGURIAN SEAS FROM MAY 1961 TO NOVEMBER 1962. E. Cerrai, L. Pelati, B. Schreiber, and C. Triulzi (Laboratori CISE, Milan and Universita, Parma, Italy). Energia Nucl. (Milan), 10: 315-18(June 1963). (In English)

Gross beta radioactivity was determined in 31 samples of plankton collected in the Adriatic and Ligurian Seas from May 1961 to November 1962. Some decay curves are reported which show approximate half lives similar to those of mixtures of fission products. The specific activities of samples are given at 15, 200, and 365 days after collection. The experimental results are plotted against the date of collection and a correlation is shown between the activity level and the occurrence of atmosphere nuclear tests. (auth)

**31846** $Sr^{90}$ CONTAMINATION OF MEN CAUSED BY FOOD UPTAKE. H. Seidler, M. Haertig, and K. Siebert (Institut für Ernährung der Deutschen Akademie der Wissenschaften zu Berlin, Bereich Verarbeitung der Lebensmittel, Potsdam-Rehbrücke, Ger.). Kernenergie, 6: 290-4(June 1963). (In German)

During 1961 in determined periods, the total food of 4 groups of persons was collected and investigated for $Sr^{90}$. Parallel to that, analytical determinations were made of the $Sr^{90}$ contents of the chief foods and the statistically determined consumed amount and the daily $Sr^{90}$ load to various groups of persons were calculated. There was very little difference between the calculated and measured values of $Sr^{90}$ activity in food. For babies and small children it amounted to about 5 pC $Sr^{90}$ per person per day and for children, youths, and adults about 10 pC $Sr^{90}$ per person per day. (tr-auth)

**31847** $Mn^{54}$ CONCENTRATION FROM FALL-OUT IN RELATION TO THE AGE AND ORGANS OF UNIO MANCUS ELONGATULUS (MOLLUSCA, LAMELLIBRANCHIA). P. Gaglione and O. Ravera (Euratom, Ispra, Italy). Rend. Ist. Lombardo Sci. Lettere, B, 96: 157-64(1962). (EUR 254.i). (In Italian)

$Mn^{54}$ is an activation product of the shell of the atomic bombs. This radionuclide in fallout and in biological material collected in Northern Italy was not ordinarily found. The Unionidae represent an exception, because in these organisms a certain amount of radiomanganese (Mn-54) was measured. The results from the spectrometric analysis carried out on Unio mancus var. elongatulus, Pfeiffer, collected near Angera (Lago Maggiore), show clearly a very strong correlation between the $Mn^{54}$ concentration and the age of the Mollusc. In addition, the $Mn^{54}$ content in the different parts of the body of Unio is very different. (auth)

**31848** DIFFERENTIAL ACCUMULATION OF $I^{131}$ FROM LOCAL FALLOUT IN PEOPLE AND MILK. R. C. Pendleton, C. W. Mays, R. D. Lloyd, and A. L. Brooks (Univ. of Utah, Salt Lake City). 29p. (CONF-66-1)

From Symposium on the Biology of Radioiodine, Richland, Wash., June 1963.

Marked differences in accumulation of $I^{131}$ in milk and people were recorded along fallout trajectories with origins at the Nevada Test Site. Iodine-131 in milk was measured from 39 dairy farms situated in geographically and ecologically different areas of Utah, and in 28 persons residing on these farms. Total $I^{131}$ intake during this incident, assuming consumption of 1 liter of milk per day, ranged from 0 to 800,000 picocuries. Total body and thyroid burdens of people from farms paralleled levels in milk produced on their farms. Accumulation in milk was correlated with feeding practices, and highest levels occurred on farms at high altitudes. Highest accumulation was found in milk and people from farms where cattle were fed green chop alfalfa or were grazing on wet meadows. Little $I^{131}$ appeared in the milk of cattle fed uncontaminated feed which had been stored prior to the arrival of fallout. (auth)

**31849** THYROIDAL DEPOSITION IN MAN, RAT AND DOG OF RADIOIODINE FROM MILK AND NON-MILK SOURCES. C. L. Comar, R. A. Wentworth, and J. R. Georgi (Cornell Univ., Ithaca, N. Y.). 12p. (CONF-66-4)

From Symposium on the Biology of Radioiodine, Richland, Wash., June 1963.

The liquid scintillation whole-body counter was adapted for measurement of thyroidal $I^{131}$ in man following administration of about 0.25 microcuries. For comparative studies of radioiodine uptake by dogs from two sources, methods were worked out for the use of $I^{131}$ and $I^{125}$ to give data on the same animal at the same time. There were no significant differences in the thyroidal uptake of radioiodine from water solution as compared to radioiodine from cow's milk in 11 adult human subjects, in rats, and in dogs. In rats and dogs there were no differences in competitive utilization from the two sources between old and young animals and in rats between raw and pasteurized milk. (auth)

## Radiation Effects on Living Tissues

**31850** (AD-294395) THERMOLUMINESCENCE AND ELECTRON PARAMAGNETIC RESONANCE OF AMINO ACIDS: POLYPEPTIDES AND PROTEINS IRRADIATED WITH ULTRAVIOLET LIGHT. Technical Report No. 2. J. Gill and M. Weissbluth (Stanford Univ., Calif. Biophysics Lab.). Oct. 1962. Contract Nonr-225(36). 105p. (BL-77)

Theories and kinetic expressions for thermoluminescence from macroscopic crystals, molecular crystals, and amorphous solids were developed. Results are reported from measurements of thermoluminescence from

amino acids, polypeptides, and proteins after exposure to ultraviolet radiation. Results are also reported from measurements of electron paramagnetic resonance in these materials after exposure to ultraviolet radiation. (C.H.)

**31851** (BNL-6989) EFFECTS OF HEAVY HIGH ENERGY CHARGED PARTICLES. III. IN VIVO ACTIVATION IN MICE OF $C^{12}$, $N^{14}$ AND $O^{16}$ BY BOMBARDMENT WITH 2 Bev PROTONS. Stuart W. Lippincott, John E. Jesseph, William H. Moore, Jr., and Rita F. Straub (Brookhaven National Lab., Upton, N. Y. and Wake Forest Coll., Winston-Salem, N. C. Bowman Gray School of Medicine). [1962]. Contract [AT(30-2)-Gen-16]. 17p. (CONF-65-1)

From Federation of American Societies for Experimental Biology Meeting, Atlantic City, N. J., April 1963.

Bombardment of mice with protons of 2 Bev energy produces the short-lived radionuclides of carbon, nitrogen, and oxygen. The gamma emission from decay of these isotopes (positron emission) can be measured and serves as a quantitative measure of total proton dose. (auth)

**31852** (BNL-7137) LYMPHOCYTE PRODUCTION MEASURED BY EXTRACORPOREAL IRRADIATION, CANNULATION AND LABELING TECHNIQUES. E. P. Cronkite, C. R. Jansen, H. Cottier, Kanti Rai, and C. R. Sipe (Brookhaven National Lab., Upton, N. Y.). [1963]. Contract [AT(30-2)-Gen-16]. 39p. (CONF-100-1)

From Meeting on Production and Maturation of Leukocytes, New York, May 1963.

The labeling of newly-formed lymph cells with tritiated thymidine, lymphatic duct cannulation, and the peripheral destruction of lymphocytes by extracorporeal irradiation of the blood were used to estimate the mass of prestored lymphocytes and the relative degree of recirculation of lymphocytes from blood to lymph and back again. Topics discussed include the effects of extracorporeal irradiation on the histologic picture of the lymphoreticular tissue, the influence of extracorporeal irradiation upon the thoracic duct output, and preliminary observations on labeling of lymphocytes by tritiated thymidine at the completion of extracorporeal irradiation. Data indicate that the mass of preformed small lymphocytes may be as large as 40 times that present in peripheral blood, that the blood feeds lymphocytes primarily into the lymph, and presents strong evidence for lymphocyte recycling. (C.H.)

**31853** (LADC-5618) GENETIC EFFECTS OF X IRRADIATION OF 10, 15, AND 20 GENERATIONS OF MALE MICE. J. F. Spalding, M. R. Brooks, and R. F. Archuleta (Los Alamos Scientific Lab., N. Mex.). [1963]. Contract W-7405-eng-36. 12p. (CONF-67-16)

From Health Physics Society Annual Meeting, New York, New York, June 1963.

Male mice were exposed to 200 rads of x rays (acute whole body exposures) for 20 consecutive generations. Comparative studies were done on breeding characteristics of offspring from 10 and 15 generations of irradiated males. Irradiated line mice were less efficient breeders than were control line mice, and the decrement increased with the number of generations irradiated. Female mice from 10 to 20 generations of irradiated males were studied for resistance to low intensity $\gamma$-rays and were found to be less resistant than control line mice. It was concluded that x irradiation to consecutive generations of male mice produces a genetic decrement affecting both breeding and efficiency and stamina. (auth)

**31854** (TID-19067) EFFECT OF IONIZING RADIATION ON FOREST TREES—ITS GENETIC AND CYTOLOGICAL IMPLICATIONS. Progress Report, June 1, 1961–May 31, 1963. François Mergen (Yale Univ., New Haven. School of Forestry). July 1, 1963. Contract AT (30-1)-2755. 17p.

Progress is reported in a study of the effects of ionizing radiation on the reproductive process and survival of forest trees. Data are presented from studies on the effect of low level chronic $\gamma$ irradiation on a pitch pine-oak forest. It was shown that the initiation of reproductive primordia in Pinus rigida, Quercus ilicifolia, Quercus alba, and Quercus coccinea is not unusually sensitive to irradiation. Spring flushing and growth were retarded in irradiated seedlings of Pinus rigida. Preliminary data are included from a study of the effects of chronic $\gamma$ radiation at doses ranging from normal background to 840 r/day delivered during a 16 to 20 hr exposure on a terrestrial ecosystem and its components. (C.H.)

**31855** (TID-19126) INSTITUTE IN FUNDAMENTALS OF RADIATION AND RADIOLOGICAL PROTECTION. Final Report, June 9, 1962 through May 30, 1963. (North Carolina State Coll., Raleigh and North Carolina. Univ., Chapel Hill). Contract AT(40-1)-2977. 93p.

An outline is presented of a course in the basic principles of radiological protection for public health officials and other personnel who have some specific responsibility for organizing, training, and providing for the protection of the public from the hazards of radiation. An evaluation is included of the effectiveness of the course in obtaining objectives after one year. (C.H.)

**31856** (TID-19166) SOMATIC MUTATIONS IN THE MOTH EPHESTIA. Progress Report. Ernst W. Caspari (Rochester, N. Y. Univ. Coll. of Arts and Science). Aug. 2, 1963. Contract AT(30-1)-2902. 25p.

The scales on the hind wing of the moth Ephestia were used as an example of a developing and differentiating system in studies of the effects of x radiation and chemical mutagens on the genetic structure of developing cells. The chemical mutagens used included 5-bromodesoxyuridine (5-BDU), 5-bromouracil, 2-aminopurine, and 5-BDU plus thymidine. Very little effect was observed after treatment with 2-aminopurine and 5-bromouracil. Possible reaction mechanisms involved in the genetic action of 5-BDU and x radiation are discussed. (C.H.)

**31857** (UCD-107) THE EFFECTS OF X-RADIATION ON WORK CAPACITY AND LONGEVITY OF THE DOG. Annual Progress Report No. 12 [on] LONG TERM EFFECTS OF X-RADIATION ON THE BEAGLE. A. C. Andersen (California. Univ., Davis. School of Veterinary Medicine). June 1963. Contract AT(04-3)-472. 288p.

Separate abstracts were prepared on 11 sections of this report. (C.H.)

**31858** (UCD-107(p.7-12)) KENNEL MANAGEMENT AND CLINICAL OBSERVATIONS. R. M. Johnson (California. Univ., Davis. School of Veterinary Medicine).

A brief review of animal caretaker organization and responsibility is presented, with orientation toward maintaining continuity throughout this long term experiment. During the past year, six animal caretakers have cared for 350 beagles. Of these 258 (74%) are aging following whole-body x-irradiation at or near puberty. The remainder constitute a continuous reproductive fitness program, following an MLD. Eighty litters were whelped in this colony during the past year, totaling 370 pups, of which 78% were weaned. Routine care and observation of the aging, irradiated dogs make up the major work load of the kennel. Conditions requiring special clinical attention may be observed

by the caretakers during daily surveillance and referred to the veterinarian, or they may be detected by him during the semi-monthly examinations. The incidence of various conditions receiving special attention during the past year is summarized. (auth)

**31859** (UCD-107(p.13-29)) ANNUAL EXAMINATION OF CONTROL AND X-IRRADIATED BEAGLES. R. M. Johnson (California. Univ., Davis. School of Veterinary Medicine).

Annual examination of a colony of control and x irradiated beagles revealed a continuous increase in mammary tumors, heart defects, skin conditions, and wearing of occlusal surface of the teeth, as the mean age of the dogs has reached 3365 days, or nearly ten years. (auth)

**31860** (UCD-107(p.30-43)) DETECTABLE MAMMARY TUMORS IN AGEING X-IRRADIATED AND CONTROL BEAGLES. R. M. Johnson (California. Univ., Davis. School of Veterinary Medicine).

The location, size, and consistency of mammary tumors with advancing age of the colony are presented. Mammary tumors are discussed from the standpoints of x ray exposure, age, and reproductive history. To date, the cumulative incidence of mammary tumors is 164 out of the total of 354 dogs in the experiment, or 46%. The incidence among the dogs living is 57% for the entire colony, and also for each group considered separately, without reference to age difference. (auth)

**31861** (UCD-107(p.44-9)) OPHTHALMOSCOPIC FINDINGS IN EXPERIMENTAL BEAGLES. W. G. Magrane (California. Univ., Davis. School of Veterinary Medicine).

Findings are reported from gross and ophthalmoscopic examination of the eyes in aging irradiated and non-irradiated dogs. Significant lenticular opacities were observed in the irradiated group. (C.H.)

**31862** (UCD-107(p.50-73)) CARDIOVASCULAR DISEASE IN AGEING CONTROL AND IRRADIATED BEAGLES. R. M. Johnson (California. Univ., Davis. School of Veterinary Medicine).

Auscultatory and electrocardiographic findings disclosed 6% incidence of heart disease in a colony of aging control and irradiated beagles. Differences between treatment groups were not significant, since they are probably more closely related to the age of the dogs than to the level of x irradiation received. Although evidence of heart defects were found at necropsy, deaths were not attributed to primary cardiac disease. (auth)

**31863** (UCD-107(p.74-85)) DEVELOPMENT OF A PSYCHOLOGICAL FIELD RESEARCH PROGRAM. A. K. Solarz (California. Univ., Davis. School of Veterinary Medicine).

Adaptation of observational techniques to the evaluation of behavioral patterns in an aging colony of purebred beagle dogs was subject to certain limitations imposed by the structural design, e.g., penning of the dogs in pairs; the considerable age range (5 to 10 years); and the predetermined size, shape, and location of the pens. These restrictions were not necessarily disadvantageous, and were offset to a considerable extent by the existence of the continuing program, with established routines and complete medical life-history records. Field research methods were of necessity limited to three classes: naturalistic observation, naturalistic manipulation, and field experiment studies. The principal task in setting up a program was the translation of defined behavioral dimensions to the dog. A list of 18 response classifications which seemed to be most meaningful for the dog was selected. The four major categories of behavior thus brought into investigative focus were: activity cycles, dyadic relationships, affective responses, and learning-memory. A lookout tower, equipped with binoculars and monoscope, was designed and built to provide an advantageous position from which the observer could view many dogs at once, while remaining unobserved by them. (auth)

**31864** (UCD-107(p.86-97)) PSYCHOLOGICAL STUDIES—DYADIC DOMINANCE-SUBMISSION PATTERNS IN FEMALE BEAGLE DOGS. A. K. Solarz (California. Univ., Davis. School of Veterinary Medicine).

The two basic questions as to whether dominance-submission in a dyadic relationship may suppress or facilitate specific bodily processes in aging beagle dogs under specified kennel conditions, and whether whole-body x irradiation affects this dyadic relationship, were investigated. Preliminary trends reported suggest that either dominance or submission may act as a stress to the dog. Data thus far accumulated indicate that submissive dogs tend to be less well in general appearance, and that dominant dogs tend more toward obesity. Further observations and statistical analysis are in progress. (auth)

**31865** (UCD-107(p.98-111)) THE EFFECT OF TOTAL-BODY IRRADIATION ON REPRODUCTION. PART I. REPRODUCTIVE ABILITY OF AGING X-IRRADIATED AND SHAM-TREATED FEMALE BEAGLES. A. C. Andersen (California. Univ., Davis. School of Veterinary Medicine).

Reproduction was not seriously impaired by total-body x irradiation of female beagles. Estrous periods in control and irradiated dogs compared favorably until early senescence. There was no evidence that either fertility or the ability to raise young to the weaning age was impaired in survivors of mid-lethal exposure given during puppyhood, or at puberty. (auth)

**31866** (UCD-107(p.112-28)) THE EFFECT OF TOTAL-BODY IRRADIATION ON REPRODUCTION. PART II. SYNDROMES AFFECTING REPRODUCTION IN X-IRRADIATED AND CONTROL FEMALE BEAGLES. A. C. Andersen (California. Univ., Davis. School of Veterinary Medicine).

Since female beagles surviving mid-lethal doses of total-body x irradiation showed no impairment of fertility, effects of the radiation on the ovary were examined. It was found that benign neoplasms commonly observed in the ovaries of aging normal dogs frequently had malignant counterparts in the ovaries of aging x irradiated dogs. These ovarian neoplasms had their origin from the surface epithelium. (auth)

**31867** (UCD-107(p.129-274)) PATHOLOGY REPORT ON EXPERIMENTAL BEAGLES. A. C. Andersen (California. Univ., Davis. School of Veterinary Medicine).

A cumulative list is presented of all experimental and control beagles that died up to Jan. 31, 1963, or 4049 days after exposure to x radiation. The cause of death and pathological findings are included. (C.H.)

**31868** (UCD-107(p.275-81)) EXPERIMENTAL DOG SURVIVAL. A. C. Andersen (California. Univ., Davis. School of Veterinary Medicine).

The probability of survival of beagles was calculated from data accumulated during the first decade of an experiment on long-term effects of whole-body x irradiation at approximately one year of age. Survivors of an $LD_{50/30}$ study provided both survival and mortality data from which trends in life-span shortening were to evaluate total dose

and method of exposure (single or fractionated). Trends toward lower survival rate in the higher exposure groups (300 r) may be indicative of effect to be anticipated with the advent of senility in these dogs. Statistical significance has not yet been attained, but an increasing incidence of malignancies may affect results of future analyses. (auth)

**31869** ANALYSIS OF RADIATION-INDUCED GENETIC DAMAGE IN SEEDS. R. A. Nilan, C. F. Konzak, E. Froese-Gertzen, and N. S. Rao (Washington State Univ., Pullman). Abhandl. Deut. Akad. Wiss. Berlin, Kl. Med., No. 1, 141-52 (1962). (In English)

Barley seeds were used in studies of influence of pre- and post-irradiation environmental factors on genetic damage produced by radiation. It was found that under certain environmental conditions the seeds retain their ability to respond to oxygen during post-irradiation rehydration indefinitely. It appears that the critical moisture content at which aerobic rehydration post-treatment may be effective is between 10 and 12%. An interpretation is offered of the role of the following factors in production and reactions of radicals produced by radiation in seeds: kind and dose of radiation, atmosphere, moisture, temperature, and time between irradiation and hydration. Height of seedlings and frequencies of chromosome aberrations in shoot tips grown from seeds x-irradiated and then hydrated in a diethyl sulfate solution are tabulated. (40 references.) (A.G.W.)

**31870** RADIATION THERAPY WITH HIGH-ENERGY ELECTRONS USING PENCIL BEAM SCANNING. J. W. J. Carpender, Lester S. Skaggs, L. H. Lanzl, and M. L. Griem (Univ. of Chicago and Argonne Cancer Research Hospital, Chicago). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 221-30(Aug. 1963).

A partial review of the literature dealing with the clinical aspects of electron beam therapy is presented. A brief description of the pencil beam scanning electron linear accelerator at the Argonne Cancer Research Hospital is given. Brief mention of the 97 patients treated by means of this device in the past 3 years is made. The limited skin reactions observed are described. Several theoretic explanations for the limited skin reactions are briefly discussed. (auth)

**31871** THE RELATIVE SURFACE IONIZATION FOR HIGH ENERGY ELECTROMAGNETIC RADIATION. J. L. Howarth (Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 231-9(Aug. 1963).

A theoretical method is presented for predicting the relative skin surface ionization for x-ray or $\gamma$-ray beams for different energies, collimation systems, field sizes, and treatment distances. The mechanism of the subcutaneous build-up of ionization is discussed. Applications of the data in reducing skin reactions during radiotherapy are suggested. (C.H.)

**31872** DOSAGE TO IMPORTANT SITES IN RADIATION THERAPY OF TUMORS ABOUT THE HEAD AND NECK. R. G. Parker, P. Wooton, and L. Burnett (Univ. of Washington, Seattle). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 240-5(Aug. 1963).

In the treatment of tumors about the head and neck with a commercially available $Co^{60}$ teletherapy unit at 80 cm source skin distance, incidental dosage to various sites outside the volume of interest may be greatly reduced by additional collimation. Therefore, such collimation would seem a part of good technique. Values recorded for the $Co^{60}$ apparatus with additional collimation and the Van de Graaff apparatus without additional collimation are comparable. Such additional collimation makes no significant difference with the 2 Mev Van de Graaff apparatus used as a roentgen-ray source and minimal difference in use of 300 kv peak (half value layer of 3.0 mm Cu) roentgen-ray apparatus. In standard techniques for radiation treatment of tumors about the human head, incidental radiation to important sites such as the lens, posterior orbit, brain stem, cervical spinal cord, mandible, and thyroid may be of some magnitude. Inasmuch as these dosages have been tolerated in a large number of long term survivors, such information should not lead to a curtailment of these techniques, but rather to an appreciation of the tolerance of normal tissues. (auth)

**31873** OFFICE RADIOBIOLOGY AND THE TEST OF DIVIDED-DOSE IRRADIATION. Paul W. Scanlon (Mayo Clinic and Mayo Foundation, Rochester, Minn.). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 269-79(Aug. 1963).

A simple and quantitatively accurate radiobiologic test system for office use by the clinical radiotherapist is described. Radiation inhibition of Lemna minor, or duckweed, grown in an aquarium, forms the basis of the test system. Results are reported from radiation-inhibition studies using this system with time-dose variables appropriate to the radiation dose. The system proved adequate for testing the relative biologic effectiveness of the various quantities of radiation employed in clinical radiotherapy. (C.H.)

**31874** THE ACUTE EFFECTS OF RADIATIONS ON THE PHYSIOLOGY OF SMALL BLOOD VESSELS. William T. Moss and Sandra Gold (Northwestern Univ., Chicago; Veterans Administration Research Hospital, Chicago; and Chicago Wesley Memorial Hospital). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 294-9(Aug. 1963).

Radiation-induced functional changes in small blood vessels were studied at 3 intervals. The nature and magnitude of these changes are discussed together with speculation concerning their causes. (auth)

**31875** FURTHER STUDIES ON ONCOLYSIS ENHANCEMENT. PLASMA CONSTITUENTS PRODUCED BY WHOLE BODY IRRADIATION. Melvin R. Sikov and James E. Lofstrom (Wayne State Univ., Detroit). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 300-10(Aug. 1963).

We have demonstrated that the injection of plasma from previously irradiated rats will increase the amount of oncolysis resulting from irradiation of the tumor. This effect can be demonstrated at 10 minutes, 1 day, and 5 days after irradiation but is absent at 1 hour and 3 days, indicating that multiple materials are involved. One of these is present at 5 days after whole-body irradiation; this migrates with the alpha-2 globulins and is destroyed by lyophilization. Another portion of the effect is associated with complement or some other naturally occurring substance in the blood of normal rats. (auth)

**31876** DETERMINATION OF THE DISTRIBUTION OF $P^{32}$ IN PHANTOMS AND IN PATIENTS BY DETECTION OF BREMSSTRAHLUNG RADIATION WITH A SCINTISCANNER. Joan G. Heidelberg, Paul G. Sirota, William C. Dewey, and Raymond G. Rose (Univ. of Texas, Houston). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 325-35(Aug. 1963).

A method is presented in which the distribution of $P^{32}$ labeled colloidal chromic phosphate, used for radiation therapy, can be determined. This method requires only the conventional scintillation detection equipment and can

be used either with or without pulse-height analysis. For in vivo studies, an automatic scintiscanner is desirable, although photoscanning equipment is not necessary. The resolution is comparable to that obtained with $I^{131}$, and the sensitivity is adequate for the therapeutic use of $P^{32}$. The sensitivity was determined with a 2-inch NaI crystal and 7-hole collimator. For a 3-cm cube filled with $P^{32}$ and placed below 0.1 cm of water, the sensitivity was 31,000 cpm/mc. The sensitivity was reduced to 11,000 cpm/mc when the cube was placed below 8 cm of water. (auth)

**31877** RADIOENCEPHALOGRAPHIC SCANNING WITH POSITRON-EMITTING $As^{74}$. J. Donald McQueen (Baltimore City Hospitals and Johns Hopkins Univ., Baltimore). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 336-44(Aug. 1963).

The use of intracarotid injections of $As^{74}$ for coincidence counting brain tumor surveys is described. These may be administered to selected patients at the time of angiography. The dosage is reduced to 500 $\mu$c per 70 kg; the resulting internal radiation is 0.7 rad. Intrinsic tumor images are intensified. Other patients receive an intravenous injection which is reduced to 750 $\mu$c (giving 1.0 rad internal radiation). The 24 hour scans are abandoned. For hemispheral tumors, the complementary use of angiography with scanning surveys is expedient in most instances. (auth)

**31878** AFTERLOADING IN INTERSTITIAL AND INTRACAVITARY RADIATION THERAPY. Ulrich K. Henschke, Basil S. Hilaris, and G. D. Mahan (Memorial Hospital for Cancer and Allied Diseases, New York; James Ewing Hospital, New York; and Sloan-Kettering Inst. for Cancer Research, New York). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 386-95(Aug. 1963).

Afterloading techniques eliminate radiation exposure for most hospital personnel, satisfy federal, state, and city regulations, add to the convenience of the physician, and improve the care of the patients. (auth)

**31879** TESTING RADIUM CAPSULES FOR RADON LEAKAGE. Robert G. Gallaghar (Applied Health Physics, Inc., Pittsburgh), Robley D. Evans, and R. G. McAllister. Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 396-402(Aug. 1963).

Sealed radium sources are used, predominantly, for medical purposes in this country. Expensive spills of the radium salt are on record. Careful handling, periodic examination, testing for radon leakage, and re-encapsulation should be provided for all sealed radium sources. Aside from the potentially severe health hazard, careful attention to maintenance of the hermetic seal of radium sources is important for 2 reasons: a spill of the finely divided radium salt can be highly expensive to clean up, and the source does not deliver the gamma dose expected of it unless the radon daughters are in equilibrium with the parent radium. A new, more sensitive, electrostatic precipitation method of leak testing sealed radium sources has been developed and field tested for several years. This method is far more sensitive than earlier methods and a time-saver during field surveys. Radiological safety surveys in 24 hospitals and 3 doctors' offices revealed 37 leaking radium sources out of a total of 664 leak tested (total of 4,318 mc). Leaking sources contaminate storage safes, handling equipment and applicators. It is concluded that sealed radium sources should be tested for radon leakage annually and that such sources should be routinely re-encapsulated every 10 years to relieve the internal gas pressure caused by inevitable accumulation of helium when $\alpha$ particles capture electrons and become helium atoms. (auth)

**31880** SIMPLE TEST FOR LEAKING RADIUM SOURCES. John E. Rose (Argonne National Lab., Ill.). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 403(Aug. 1963).

A simple, sensitive, reliable, and inexpensive test for leaking radium sources consists of placing the source in a test tube or screw-top glass bottle with a loosely packed ball of surgical cotton with a volume of 2 or 3 cu in. The container is closed overnight. The cotton is removed after 16 to 48 hr and checked for activity above background with a survey meter provided with earphones. (C.H.)

**31881** IONIZING RADIATION AND THE CELL. Roy Waldo Miner, ed. Ann. N. Y. Acad. Sci., 59: 467-664 (Feb. 3, 1955).

Topics discussed at this conference include: applications of ionizing radiation in determining biological structure; radiation studies of proteins and enzymes; radiation effects in viruses; the use of charged particles to measure skin thickness and other surface properties; the effect of chromosomal and extrachromosomal irradiation on chromosome movements; the effects of x rays, electrons, and neutrons on dormant barley seeds; radioinduced forward and reverse mutation; cytochemical effects of radiation; radiation effects in aqueous solutions and systems of biological importance; the sensitivity of bacteria to high-velocity electrons; the influence of pre- and post-treatments on bacterial inactivation by ionizing radiations; radiation effects in Paramecium; and factors affecting the radiosensitivity of mammalian cells. (C.H.)

**31882** EVIDENCE FOR INDIRECT EFFECTS OF RADIATIONS OF HEAVY IONS AND ELECTRONS ON HAIR DEPIGMENTATION. Herman B. Chase, William E. Stralle, and Claudette Arsenault (Brown Univ., Providence). Ann. N. Y. Acad. Sci., 100: 390-8(Feb. 15, 1963).

Localized irradiations of hair follicles of mice, made possible by short-range heavy ions from a heavy ion linear accelerator and by collimated narrow slit beams of accelerated electrons, demonstrate depigmentation effects remote from the site of original irradiation damage and also depigmentation effects delayed until the second hair growth following irradiation. To explain these indirect effects, the tentative hypothesis is again proposed that suggests that the upper permanent external sheath is the true germ. It produces the new lower external sheath and bulb of each hair generation, and damage from irradiation causes it to fail in its capacity of incorporating and culturing the potential melanocytes which are present primarily in the dermal papilla or the resting epithelial tab conventionally called the germ. In any case, with respect to pigmentation and melanocytes, there are indirect effects of irradiation. (auth)

**31883** INVESTIGATIONS ON THE BIOLOGICAL EFFECT OF A LOCALIZED IRRADIATION ON A COMPLEX ORGANISM. A. Chevallier, S. Manuel, and D. Chateau (Faculté de Médecine, Strasbourg). Ann. Radiol., 6: R239-50(1963). (In French)

The study of the biological effect of a localized x radiation on a mammal requires the establishment of a precise and rational test of effects. The physiological conditions under which counting of the cells in the femur bone marrow of the rat and the experimental set-up to give well-defined localized irradiations are described. The side effects are caused either by the action of corticoid hormones or by

scattered radiation. These two factors can be sufficiently reduced to obtain a pure radiological effect. Under such conditions the irradiation, even at high doses, has no perceptible distance-action. Irradiation of the adrenals induces an important decrease of cells of the femoral bone marrow, analogous to that produced by "stress." Irradiation of other body segments has no effects on animals that have previously received an adequate dose of morphine. It is possible to observe the biological effect of irradiation "in its pure form" and to define the effect of precise radiation doses. (J.S.R.)

**31884** SUBSTRATE INDUCTION OF AN ENZYME SYSTEM OXIDIZING TYROSINE IN IRRADIATED ANIMALS. T. N. Protasova. Biochemistry (USSR) (English Transl.), 27: 455-7(Nov.-Dec. 1962).

The capacity for substrate induction of the tyrosine oxidase system is retained by rats after exposure to a lethal dose of $\gamma$-irradiation from a $Co^{60}$ source. The induction effect is of about the same magnitude in irradiated as in normal rats. Substrate induction is absent from adrenalectomized animals, both before and after irradiation, but is restored by administration of cortisone. (auth)

**31885** THE ACTION SPECTRA FOR ULTRAVIOLET-LIGHT INACTIVATION OF SYSTEMS CONTAINING 5-BROMOURACIL-SUBSTITUTED DEOXYRIBONUCLEIC ACID. I. ESCHERICHIA COLI 15 T⁻A⁻U⁻. Richard Boyce (Yale Univ., New Haven) and Richard Setlow. Biochim. Biophys. Acta, 68: 446-54(Mar. 26, 1963). (In English)

Cells of Escherichia coli T⁻A⁻U⁻ had 22% of their thymine substituted by 5-bromouracil with no loss in viability. The ultraviolet-light sensitivity of the substituted cells is greater than that of normal cells at all wavelengths between 2300 and 3130 Å by a factor which depends on the inactivating wavelength. The wavelength dependence of the sensitivity of substituted cells is qualitatively explicable by the absorbancy differences between 5-bromouracil and thymine. However, 5-bromouracil absorption is not sufficient to account quantitatively for the wavelength dependence. The results indicate that quanta absorbed in 5-bromouracil at long wavelengths are more efficient in the inactivation process than are quanta absorbed in other bases. (auth)

**31886** THE ACTION SPECTRA FOR ULTRAVIOLET-LIGHT INACTIVATION OF SYSTEMS CONTAINING 5-BROMOURACIL-SUBSTITUTED DEOXYRIBONUCLEIC ACID. II. BACTERIOPHAGE $T_4$. Richard Setlow (Oak Ridge National Lab., Tenn.) and Richard Boyce. Biochim. Biophys. Acta, 68: 455-61(Mar. 26, 1963). (In English)

Phage in which about 80% of the thymine was replaced by bromouracil were inactivated by monochromatic ultraviolet light in the range of 2300–3131 Å. The sensitivity of the substituted phage was greater than that of normal phage by a factor which is wavelength dependent. This factor is approximately 4 between 2400 and 2900 Å, but increases to 7 at 2300 Å and to 88 at 3131 Å. The general increase in ultraviolet-light sensitivity may arise in part from impairment of enzymic reactivation and in part from the nature and extent of photoproducts produced in 5-bromouracil-substituted DNA. The long-wavelength dependence of the sensitivity is largely accounted for by the greater ultraviolet-light absorbancy of bromouracil compared with thymine. (auth)

**31887** AUTORADIOGRAPHIC INVESTIGATION ON THE INCORPORATION OF [$^3$H] AMINO ACIDS INTO THE CEL NUCLEUS DURING THE $G_1$-PHASE AND THE S-PHASE OF NORMAL AND X-IRRADIATED MICE. K. Gerbaulet, W. Maurer, and J. Brueckner (Universität, Cologne). Biochim. Biophys. Acta, 68: 462-71(Mar. 26, 1963). (In German)

The incorporation of different $H^3$ amino acids into the nuclei of some cell types of the mouse was studied by quantitative radioautography. Within all nuclei of the same cell type the incorporation per unit of cell volume was found to be nearly constant; the total incorporation of a nucleus is proportional to its volume. After simultaneous application of $C^{14}$ thymidine the nuclei in the S-phase were additionally labelled by $\beta$-traces which permits the differentiation of DNA-synthesizing nuclei from the nuclei not synthesizing DNA. For the epithelial cells of the jejunum crypts, it was shown that the $H^3$ leucine- or the $H^3$ tyrosine-incorporation per unit of nuclear volume remained constant over the generation time (except during mitosis). Whole-body irradiation with doses up to 800 R had no effect on the incorporation of $H^3$ leucine or of $H^3$ tyrosine into the nuclei of the epithelial cells of the liver and of the jejunum crypts within the first 2 hr after irradiation. (auth)

**31888** RADIOPROTECTION AND MODIFICATIONS INDUCED BY CYSTEAMINE. Fr. Horvat and A. Gilles (Université, Louvain, Belg.). Bull. Classe Sci. Acad. Roy. Belg., Ser. 5, 48: 1315-18(1962). (In French)

The effects of cysteamine on the structures and chromosomic behavior in Pisum sativum were investigated. The effects are typically radiomimetic. The results, extending those obtained with respect to the effect of cysteamine on the mitotic phenomena and developments, help define the precise role played by cysteamine in cellular mechanisms. (tr-auth)

**31889** RADIATION KILLS BACTERIA IN FROZEN EGGS. G. W. Anderson and A. G. Comer (Ontario Agricultural Coll., Guelph). Can. Nucl. Technol., 2: No. 3, 48-9(1963).

Studies were conducted on the possible use of $Co^{60}$ gamma rays to kill Salmonella bacteria in eggs. These studies included pure cultures of various Salmonella species, commercial eggs, and inoculated eggs. The survival curves of all the species were found to follow the same general pattern, and the dose for $10^7$-fold reduction varied from 0.54 Mrad for S. give to 0.36 Mrad for S. senftenberg. The radiosensitivity of each species, however, is not constant but varies over a small range. It is concluded that a dose of 0.54 Mrad is required for safe reduction of the most resistant Salmonella species in eggs. (D.L.C.)

**31890** DEPENDENCE OF THE REGENERATION OF IRRADIATED CELLS ON THE TYPE OF ENERGY METABOLISM. L. A. Seliverstova and M. N. Meisel (Inst. of Microbiology, Academy of Sciences, USSR). Dokl. Akad. Nauk SSSR, 150: 1366-9(June 21, 1963). (In Russian)

Regeneration of monocellular organisms exposed to ionizing radiation occurs primarily if the basal metabolism of the system is reduced under conditions of continued endogenic respiration. Aerobic and anaerobic cultures of Saccharomices vini (ellipsoideus) and of Saccharomices cerevisiae were used for studying the regeneration process. The cultures were exposed to x radiation at a dose rate of 3560 r/minute for integral dose of 100 kr. The degree of regeneration was determined on the basis of the number of colonies after 3 days of growth in water, in comparison with unirradiated cells. Saccharomices vini exhibited considerably less regenerative capacity after irradiation when growing under anaerobic conditions than when

the cells were growing under aerobic conditions: after 4 days of incubation 84% of the cells were regenerated in the first case and only 50% in the second case. Similar results were obtained with Saccharomices cerevisiae and also when the culture period was extended. One of the reasons for this behavior is probably the fermentative reorganization of the mitochondria. (TTT)

**31891** COMPARISON OF THE HARMFUL EFFECTS OF FAST NEUTRONS AND X-RADIATION ON THE GONADS OF MICE. M. D. Pomerantseva and L. K. Ramaiya (Inst. of Genetics, Academy of Sciences, USSR). Dokl. Akad. Nauk SSSR, 150: 1370-2(June 21, 1963). (In Russian)

In view of the contradictory data in the literature on the radiation sensitivity of the gonads of mammals, the relative biological effectiveness (RBE) of fast neutrons was studied on 3-month-old white mice. The animals were exposed to total doses of 20, 50, 100, 200, 300, 400, 600, 800, and 1600 r of x radiation and to 17, 34, 57, 114, 171, and 228 rad of fast neutrons in the horizontal beamhole of an IRT-type reactor. The degree of damage of the gonads was determined on the basis of the changes in their weight and their histological picture. It was found that in every case the largest weight loss occurred 28 days after the irradiation. Even small doses caused a relatively large reduction in the weight, but the rate of the weight reduction decreased with increasing integral doses. This is due to the fact that the embryonic epithelium disappears as a result of the exposure to radiation and at large doses only relatively radiation-resistant components are present in the gonads. For both types of radiation, a linear correlation was found to exist between the weight-loss rate and the logarithm of the dose; 206 ± 3 r of x radiation and 54 ± 2 rad of fast neutron dose caused a weight loss of 50%. The RBE of fast neutrons is thus found to be 3.5 in average. (TTT)

**31892** MUTAGENIC EFFECTS OF X-RAYS AND FORMALDEHYDE FOOD IN SPERMATOGENESIS OF DROSPHILA MELANOGASTER. H. Slizynska (Inst. of Animal Genetics, Edinburgh). Genet. Res., 4: 248-57(July 1963).

The structural changes induced by x ray in cells at different stages of spermatogenesis were analysed in salivary gland chromosomes of Drosophila melanogaster and compared with the changes induced by formaldehyde added to the food (FF) of the larvae. The different stages of spermatogenesis vary in sensitivity to x rays when measured by the percentage of sex-linked lethals, by the percentage of spermatozoa carrying structural changes, and by the number of changes per 100 spermatozoa. The proportions of the different types of change (T, In, Rp, Df), however, are fairly similar in all stages of spermatogenesis, but entirely different from those found after FF treatment. This suggests that it is the mutagen and not the sensitive stage which is responsible for the characteristic pattern of the FF effects. The differences between the effects of x ray and of FF are attributed to the different proportions of potential breaks induced by these two mutagens. Evidence has been presented indicating that while most of FF induced breaks are potential (about 73%), most of the x-ray induced breaks are immediate. For the dose rate used in the present experiment (below 1000 r/min.) only a small proportion (4-10%) of breaks induced by x ray was found to be potential. (auth)

**31893** FORMAL AND PHYSIOLOGICAL GENETICS OF ASCOSPORE COLOUR IN ASPERGILLUS NIDULANS. D. Apirion (Glasgow Univ.). Genet. Res., 4: 276-83(July 1963).

By nitrous acid or uv treatment ascospore color mutants of two kinds, blue and colorless, were obtained in Aspergillus nidulans (ascospores of wild-type are red). Four blue mutants were located in linkage group II within 0·5 unit of one another. Of the colorless mutants, four were located in linkage group I within one unit of one another, and one in linkage group IV. In diploids the mutants were recessive. Colorless were epistatic to blue. In crosses these characters behaved as non-autonomous both in the ascospores and in the asci, and all the ascospores of the asci in one perithecium as well as the perithecium wall were of the same color. In crosses between strains with blue perithecia and strains with colorless perithecia, red, blue and colorless perithecia were found; each type included both crossed and selfed perithecia. Red selfed perithecia were of either parental genotype but blue or colorless selfed perithecia always had the corresponding genotype. The phenotype of the perithecium (perithecial wall and ascospores) is considered to be determined by the homo- or heterokaryotic constitution of the protoperithecium from which it originated. (auth)

**31894** PATTERNS OF SPONTANEOUS AND RADIATION INDUCED MUTATION RATES DURING SPERMATOGENESIS IN DROSOPHILA MELANOGASTER. Philip T. Ives (Amherst Coll., Mass.). Genetics, 48: 981-95(Aug. 1963).

The daily pattern of mutational response to gamma rays was determined for three types of young adult, heterozygous, Oregon-R males which were mated exhaustively during days 1 to 12 after irradiation. Doses of 250r, 500r, and 1kr were tested for the production of dominant visible and sex-linked hemizygous mutations, and 1kr for Y and autosomal translocations. Translocations were also scored in tests of irradiated mature sperm, and of sperm maturing five to six days later, after doses of 250r, 500r, 2kr and 4kr. The observed pattern was that of an even rate for the visibles, chiefly Minutes, and was U-shaped for sex-linked mutations, chiefly lethals, with the lower rate appearing in sperm from days 2 to 8. A linear relationship with dose is indicated for the rates of all types of induced point mutations in sperm from days 1 to 6. In premeiotic stages of spermatogenesis the relationship varies between dosage levels and between the types of heterozygous males tested. Sperm derived from gonial cells which did not mutate at the time of exposure to doses of 1kr to 5kr showed that the same rate of spontaneous mutations occurred in subsequent stages of spermatogenesis as occurred in the sperm of similarly aged Control males. After 1kr, day-5 sperm showed 3.7 times more sex-linked mutations than appeared in sperm from days 1 to 3, and day-6 sperm showed 11.6 times more translocations. This favors the view that changes in mutation frequency during days 1 to 6 reflect changes in the rate at which both point mutations and chromosome rearrangements occur during the various stages of spermatogenesis from meiosis to maturity. The rate of translocations increases at approximately the 1.6 power of the increase in dose in both mature sperm and sperm maturing five to six days after irradiation, and the rate of point mutations increases linearly at both of those times. This supports the view that the mutation process does not change during the meiosis-to-maturation period of spermatogenesis. At the time of peak response in meiosis-spermiogenesis, as well as in mature sperm, after 250r to 1kr, dominant visibles appear to be a mixture of point and position-effect mutations. Increasing the time required for development by lowering the temperature increases proportionately the number of days to the peak mutational

response in irradiated sperm. This favors the interpretation that peak mutation rates are associated with specific stages in spermatogenesis. (auth)

**31895** INDUCED MUTATION RATES IN SPERM TRANSMITTED TO SONS AND DAUGHTERS IN DROSOPHILA MELANOGASTER. S. Abrahamson and E. Himoe (Univ. of Wisconsin, Madison). Genetics, 48: 1085-7 (Aug. 1963).

Irradiated second chromosomes in wild-type Drosophila melanogaster males were scored for induced lethal frequencies when transmitted to male and female progeny. No difference was observed between these two groups, and it has been concluded that the sex of the zygote which receives the irradiated chromosome does not influence the frequency of lethal mutations recovered. (auth)

**31896** STUDIES ON SENSITIVITY OF GASTROINTESTINAL TRACT AGAINST RADIOACTIVITY AND PRODUCTION OF EXPERIMENTAL GASTRIC ULCER BY LOCAL IMPLANTATION OF RADIO COLLOID. Kazuo Uegaki (Hiroshima Univ.). Hiroshima Igaku, 10: 271-98 (Nov.-Dec. 1962). (In Japanese)

Colloids of $Au^{198}$, $NaI^{131}$, and $Lu^{177}$ $Cl_3$ in small vinyl tubes, diluted to provide a wide range of radiation activities, were implanted at various locations along the gastrointestinal tract. The radiosensitivity of the various segments of the gastrointestinal tract was determined in animals sacrificed at various intervals after the implantations were made. The protective effects of cortisone, ACTH, insulin, atrophine, and chloropromazine against lesions induced by implants of colloidal $Au^{198}$ were evaluated. The physiological effects of the 5 compounds are reviewed. The possible relation of the effects of the compounds on control of gastric secretion of HCl and their protective effects against radiation injury to the gastrointestinal tract is considered. (C.H.)

**31897** INFLUENCE OF RADIATION-INDUCED CHROMOSOMAL ABERRATIONS ON THE VIABILITY OF TUMOUR AND NORMAL MAMMALIAN CELLS. METHOD OF BIOLOGICAL DOSIMETRY. I. M. Shapiro, Z. N. Faleyeva, and I. B. Smirnova (Severtzov Inst. of Animal Morphology, Moscow). Intern. J. Radiation Biol., 6: 305-22(Apr. 1963). (In English)

The hypothesis that tumor cells with radiation-induced asymmetrical exchanges and deletions are non-viable was checked and confirmed in two series of experiments using the hyperdiploid Ehrlich ascites-tumour cells. A conservation of chromosomal injury in rat-liver cells during interkinesis was demonstrated prior to the first mitosis after x irradiation. The possibility of using the percentage of cells with chromosomal aberrations as a criterion for determination of the radiotherapeutic dose is discussed. Chromosomal injuries seem not to be a cause of the interphase death of mouse intestinal crypt cells, but may be a cause of cellular destruction after division. A method for the evaluation of radiation dose in mammals is suggested that allows the determination of radiation injury in any part of the body. (auth)

**31898** THE ACUTE TOXIC EFFECTS OF CYSTEAMINE AND THEIR MODIFICATION BY X-IRRADIATION. E. V. Hulse (Medical Research Council, Harwell, Berks, Eng.). Intern. J. Radiation Biol., 6: 323-9(Apr. 1963). (In English)

The toxic effects of cysteamine in mice are described. A dose of just over twice the usual radioprotective dose caused severe convulsions and killed about half the injected animals. The dangers of using this compound in man are discussed. When a toxic dose of cysteamine was followed by 100 rads of x rays 2 to 15 min later, there was a statistically significant reduction in the number of deaths caused by the cysteamine. Doses of 500 to 5000 rads had no effect on cysteamine mortality. Possible mechanisms are discussed, and a radiation effect on the nervous system is thought to be more likely than a reversal of the protective effect of cysteamine. (auth)

**31899** INDUCTION BY X-RAYS OF THE DESTRUCTION OF DESOXYRIBONUCLIC ACID OF ESCHERICHIA FREUNDII. 2. STUDY OF DIFFERENT CONDITIONS CAPABLE OF MODIFYING THE DESTRUCTION. Paul M. Osterrieth (Université, Liège). Intern. J. Radiation Biol., 6: 331-41(Apr. 1963). (In English)

The destruction of DNA in Escherichia freundii irradiated and incubated in a medium that does not allow multiplication was studied. No direct correlation was observed between x irradiation and destruction of DNA and it was possible to modify mortality and DNA destruction independently. It was concluded that the destruction of DNA was induced by a secondary process, probably enzymatic, and not as a direct effect of radiation. (C.H.)

**31900** CONTRIBUTIONS TO THE STUDY OF IMMEDIATE AND EARLY X-RAY REACTIONS WITH REGARD TO CHEMOPROTECTION. VII. X-RAY-INDUCED ATHEROMATOUS LESIONS IN THE ARTERIAL WALL OF HYPERCHOLESTEROLAEMIC RABBITS. H. B. Lamberts and W. G. R. M. de Boer (Universiteit, Groningen, Netherlands). Intern. J. Radiation Biol., 6: 343-50(Apr. 1963). (In English)

The development of atheromatosis in the carotid artery of hypercholesterolaemic rabbits after x irradiation is described. Irradiation with 500 to 3000 r caused infiltration of fat, deposition of lipophages, and structural changes in the arterial wall within a few weeks. (auth)

**31901** OBSERVATIONS ON THE COMBINED EFFECT OF X-RAYS AND BOTULINUM TOXIN ON THE SURVIVAL OF MICE. A. Forssberg, G. Sundius, B. Tribukait, and Cl. Nyman (Karolinska Institutet, Stockholm). Intern. J. Radiation Biol., 6: 351-3(Apr. 1963).

When mice exposed to 760 r x radiation were given intraperitoneal injections of botulinum toxin immediately and again 7 hr after irradiation, the survival time was increased significantly. Other toxic compounds, including cyanide, strychnine, and brucine did not increase survival time of irradiated mice. Possible reaction mechanisms involved are discussed. (C.H.)

**31902** FREQUENCY OF CHROMOSOME ABERRATIONS AS A FUNCTION OF IRRADIATION INTENSITY AND THE PHYSIOLOGICAL STATUS OF BARLEY SEEDS. N. I. Nuzhdin, R. L. Dosortseva, and N. S. Samokhvalova (Inst. of Genetics, Moscow). Izv. Akad. Nauk SSSR, Ser. Biol., No. 4, 514-25(1963). (In Russian)

Seeds of two barley sorts, Odessa 17 and Hibernating Moscow, in organic and forced dormancy were exposed to γ irradiation ($Co^{60}$, doses 12 and 15 kr, respectively 423 and 55 r/min—Odessa 17, and 301 and 43 r/min—Hibernating Moscow). In seeds of forced dormancy irrespective of the germination time (immediately following irradiation or after 72 hr) high dose rate yielded a distinctly increased percentage of root cells with chromosome aberrations as compared to low dose rate. In seeds irradiated in the natural state, the effect of dose rate was variable. In the roots of seeds artificially released from organic dormancy and immediately germinated, the percentage of cells with chromosome aberrations was similar both at

a high and low irradiation intensity. In similar seeds germinated 10 days after release from organic dormancy the differences in intensity of irradiation were as complete as in seeds irradiated in forced dormancy. The effect of dose rate upon irradiation of air-dry seeds points to the conclusion that during irradiation some processes are going on in the seeds, which specify the degree of chromosome affection as manifested in aberrations in the dividing cells. The percentage of cells with chromosome aberrations depends on physical conditions of irradiation (such as type of radiation, magnitude, and power of the dose) and on the physiological state of the cells of the irradiated object. (P.C.H.)

**31903** SULFUR-35 STUDIES IN MAN: PLATELET SURVIVAL AND PLASMA AND URINARY RADIOACTIVITY ASSAYED BY BETA LIQUID SCINTILLATION SPECTROMETRY. Helen A. Vodopick and Ralph M. Kniseley (Oak Ridge Inst. of Nuclear Studies, Tenn.). J. Lab. Clin. Med., 62: 109-20(July 1963).

In vivo labeling of blood platelets with $S^{35}$ has specific advantages: metabolic incorporation into megakaryocytes provides a firm platelet label without elution; rapid excretion of unincorporated isotope reduces radiation exposure and prevents reutilization; and repeated handling of platelets is avoided. Platelet survival in man was measured with $S^{35}$. Data on urinary excretion rates and plasma levels of $S^{35}$ are presented, and methods of preparation of samples for beta liquid scintillation counting are described. (auth)

**31904** LEUKOPENIA IN RADIUM THERAPY. A. A. Klimenko (Research Inst. of Roentgen-Radiology, Ministry of Health, USSR). Med. Radiol., 8: No. 6, 3-7(June 1963). (In Russian)

The character of the leukopenic condition in oncological patients was studied during distance gamma therapy. It was found that the developing leukopenia is often of functional nature without organic involvement of the bone marrow and commonly the leukocyte count reverts to normal values without any blood stimulating therapy. Thus, not every instance of radiation leukopenia with a drop of the leukocyte count down to 3000 in 1 $mm^3$ of blood should involve an interval or premature discontinuation of telegamma therapy. The data derived may be of practical importance in the choice of the physician's tactics in incipient leukopenia during radium therapy. (auth)

**31905** PERIPHERAL BLOOD CHANGES IN THE TREATMENT OF CAPILLARY HEMANGIOMA OF THE FACE WITH FLEXIBLE $P^{32}$ APPLICATORS. N. K. Sviridov, O. S. Sergel, and G. A. Zubovskii (Research Inst. of Roentgen-Radiology, Ministry of Health, USSR). Med. Radiol., 8: No. 6, 7-10(June 1963). (In Russian)

Flexible radiophosphorus applicators were utilized in the treatment of 30 patients with capillary hemangioma of the face. A detailed clinical and fluorescent analysis of the blood revealed definite shifts during the treatment manifested by a reduced number of thrombocytes and leukocytes. Hematological shifts and fluorescent changes occurring during the process of radiophosphorus therapy are considered as the organism's reaction to the effect of $P^{32}$. (auth)

**31906** THE RELATIONSHIP BETWEEN CHANGES OF THE LEUKOCYTE COUNT IN THE PERIPHERAL BLOOD AND THE INTEGRAL ABSORBED DOSE IN COMBINED RADIUM THERAPY OF PATIENTS WITH CARCINOMA OF THE UTERINE CERVIX. V. A. Petrov, N. M. Palladiev, V. A. Repina, L. M. Stukova, and S. V. Strutsovskaya (Central Inst. of Research in Medical Radiology, Ministry of Health, USSR). Med. Radiol., 8: No. 6, 10-15(June 1963). (In Russian)

An analysis is given of alterations occurring in the leukocyte count of the peripheral blood depending on the integral doses. Under observation were 100 patients suffering from carcinoma of the uterine cervix who were subjected to a course of combined radium therapy. (auth)

**31907** BLOOD PROTEINS AND RIBOFLAVIN METABOLISM DURING RADIUM THERAPY OF PATIENTS WITH MALIGNANT NEWGROWTHS. M. M. Kubareva and E. M. Filkova (Research Inst. of Roentgen-Radiology, Ministry of Health, USSR). Med. Radiol., 8: No. 6, 15-19 (June 1963). (In Russian)

The relative composition of blood serum protein fractions and riboflavin excretion with the daily urine was studied in patients with cancer of the lung and esophagus before, during, and after radium therapy. In malignant neoplasms of the lungs and esophagus there is a disturbed correlation of blood protein fractions at the expense of a reduced albumin content and augmented level of globulins, especially $alpha_2$-globulins. The disturbances run a parallel course with the development of the disease. The riboflavin content in the daily urine varies within the same limits as in healthy persons. During radium therapy when the results are favorable the correlation of protein fractions reverted to normal values whereas in progress of the disease disturbances of the blood protein fractional composition become more pronounced. Thus, electrophoretic analysis of blood protein fractions may be used for assessing the severity of the disease in cancerous patients and the effectivenes of radium therapy. The riboflavin content in the daily urine of patients in the middle of treatment increased by 140–200% on the average, while at the end of treatment it was below the initial values. (auth)

**31908** RECEPTION OF IONIZING RADIATION BY ORGANISM. Yu. G. Grigor'ev and L. N. Kvasnikova. Med. Radiol., 8: No. 6, 85-91(June 1963). (In Russian)

Responses of animal organisms to small doses of ionizing radiation and stimulating effects of small doses on nervous reflexes were studied by testing reactions to saccharin water, plain water, and to food and water. Reflexes to food or dark room in association with radiation exposure were also studied. The results indicate that ionizing radiation is a factor in certain behavior reactions, but only through photo- and chemodynamic reception systems. The organism cannot differentiate ionization radiation as a specific stimulant or irritant. (R.V.J.)

**31909** DOSE-REDUCTION FACTOR FOR CYSTEAMINE WITH MITOTIC INDEX OF RAT BONE MARROW CELLS AS REFERENCE SYSTEM. A. Bose, S. Bose, and P. De (Chittaranjan National Cancer Research Centre, Calcutta). Naturwissenschaften, 50: 457(1963). (In English)

The efficiency of a radioprotective substance is best characterized by the dose-reduction factor (DRF), which is defined as the ratio of equi-effective doses. The DRF of cysteamine at different dose ranges was studied with the mitotic index as the reference system. Whole-body radiation doses of 400 to 800 r and cysteamine doses of 150 mg/kg of body weight were used. The results obtained were graphed and show that the mitotic index values as a function of the dose give straight lines. The DRF for cysteamine varied from 1.85 to 1.37, decreasing with increasing radiation dose, in disagreement with the results of Catsch. (J.S.R.)

**31910** EFFECTS OF PERTUSSIS SENSITIZATION AND ROENTGEN IRRADIATION ON THE ADRENAL GLANDS OF RATS AND MICE. Masanari Nakamura (Osaka City Univ.). Osaka Shiritsu Daigaku Igaku Zasshi, 11: 295-310(Oct. 1962). (In Japanese)

Histaminase activity was estimated by the coupled oxidation and deamination method in lung tissue from rats and mice following adrenal gland x irradiation, sensitization with B. pertussis, or pertussis sensitization followed by adrenal gland irradiation. Histamine activity was greatly reduced in lung tissue from animals sensitized with pertussis followed by adrenal irradiation, moderately reduced in lung tissue from pertussis sensitized animals, and slightly decreased in lung tissue from the adrenal irradiated group. The activity of succinoxidose and monoamine oxidose in lung tissue was not affected by either adrenal irradiation or pertussis sensitization. The possibility that steroid hormone balance may be affected by disturbance of the adrenal glands in animals sensitized with pertussis is discussed. (C.H.)

**31911** BIOLOGICAL EFFECT AND PROPHYLAXIS OF MICROWAVE IRRADIATION. J. Witkowicz. Prace Przemyslowego Inst. Telekomun., 11: No. 34, 47-55(1961).

Radiation hazards associated with the operation of microwave equipment are reviewed. Suggestions for the protection of personnel are included. (C.H.)

**31912** THE ACTION OF $\gamma$-RAYS ON SODIUM DEOXYRIBONUCLEATE IN SOLUTION. IV. THE MECHANISM OF DENATURATION. P. H. Lloyd and A. R. Peacocke (Oxford Univ.). Proc. Roy. Soc. (London), Ser. B, 158: 71-8(July 16, 1963).

The unusually efficient denaturation by $\gamma$ rays of sodium deoxyribonucleate (DNA) in solution was examined to confirm that it is effected by the attack of free radicals. A tenfold range of dose produced the same extent of denaturation, provided that the ratio of dose to DNA concentration was kept constant. Free radical inhibitors greatly reduced, and some even eliminated, the denaturing action of radiation, and $\gamma$ rays were less effective in the presence of chloride than of fluoride ion. It was concluded that the denaturation was effected by indirect action. The extent of denaturation did not decrease logarithmically with dose and this could be explained by different stabilities in the linkages between the base-pairs of DNA. The mechanism of denaturation is discussed. (auth)

**31913** THE RADIO-SENSITIVITY OF OOCYTES AT DIFFERENT STAGES OF MATURATION. Anita M. Mandl (Univ. of Birmingham, Eng.). Proc. Roy. Soc. (London), Ser. B., 158: 119-41(July 16, 1963).

The viability of the zygote after fertile mating was used as an index to assess the radiosensitivity of oocytes in Graafian follicles at different times before expected ovulation, and at known stages of the maturation process. Radiosensitivity increases as the interval between irradiation and expected ovulation decreases; the increase is progressive as the oocyte passes from the late dictyate (diplotene) phase through the successive stages of maturation, at least up to congression of chromosomes at first metaphase. It is estimated that radiosensitivity increases by about ten times between the earliest and the latest developmental stages studied, on the day of pro-oestrus. Oocytes in "medium-sized" follicles (irradiated 5 to 35 days before fertilization) are highly radioresistant. The estimated $LD_{50}$ for oocytes at this stage is about three times higher than that for pre-ovulatory oocytes some 14 to 15 hr before expected ovulation. The total difference between the radiosensitivity of oocytes in "medium-sized" or growing follicles, and that of oocytes at first metaphase, is of the order of ×30. X-irradiation is followed by superovulation and a decrease in the mean size of the corpora lutea of pregnancy. In general, the number of corpora lutea is inversely correlated with their mean size. The degree of superovulation is partially dependent on (a) the dose of x-rays and (b) the developmental stage of the oocytes at the time of irradiation. The radiosensitivity of the fertilized ovum, 8 to 12 hr after ovulation, is lower than that of pre-ovulatory oocytes which have reached or passed first metaphase. Subsequently, the sensitivity of the zygote decreases with advancing age. (auth)

**31914** LENGTHENED INDUCTION PERIOD OR IMMUNOLOGIC UNRESPONSIVENESS DEPENDING ON ANTIGEN DOSE IN ADULT, X-IRRADIATED RABBITS. Marvin B. Rittenberg and Eric L. Nelson (Univ. of California, Los Angeles). Proc. Soc. Exptl. Biol. Med., 113: 101-4(May 1963).

Adult rabbits were injected with either 10 mg or 100 mg of bovine albumin 24 hours after 400 r x irradiation. The dose of irradiation was shown to suppress completely the antibody response to the smaller amount of antigen but not to the larger amount. In the latter case the induction period was lengthened and a delayed antibody response was determined to have occurred sometime between the 14th and 24th day after injection. Whether antibody formation was to be suppressed or delayed could be correlated with the disappearance of radioiodinated antigen from the blood and the amount of antigen remaining. It was further shown that the 10 mg dose of antigen but not the 100 mg dose established a state of immunologic unresponsiveness to a subsequent challenge with antigen. (auth)

**31915** IMMUNOLOGICALLY PRIVILEGED SITES IN STUDIES OF POLYOMA TUMOR ANTIGENS. Karl Habel and James H. Belcher (National Inst. of Allergy and Infectious Diseases, Bethesda, Md.). Proc. Soc. Exptl. Biol. Med., 113: 148-52(May 1963).

Two polyoma tumors in mice were found to have a 1,000-fold increased transplantability if the IC or IT routes of inoculation are used instead of SC. When polyoma virus-immune mice were challenged by the IC or IT routes, the degree of demonstrable resistance was $10^5$ and $10^4$ minimal transplantable numbers of cells as compared to $10^1$ by the SC route. Mice immunized IC or SC with a single dose of x irradiated tumor cells and later challenged IC showed protection in the IC but not the SC immunized group. The ability of in vitro polyoma transformed tissue culture cells to produce tumors on inoculation of isologous adult mice was most markedly enhanced by whole-body x irradiation, but best results were obtained if IC inoculation was made into irradiated animals. (auth)

**31916** STUDIES ON FIBRINOGEN TURNOVER BEFORE AND AFTER WHOLE BODY X-IRRADIATION IN THE RAT. Gary S. Shaber and Leon L. Miller (Univ. of Rochester, N. Y.). Proc. Soc. Exptl. Biol. Med., 113: 346-50(June 1963).

The biological half life for in vivo screened $I^{131}$ labeled rat fibrinogen injected intravenously in normal rats was found to be 1.5 days. After 6 to 7 days the apparent biological half life changed to 2.7 days. The apparent whole-body turnover of $I^{131}$ fibrinogen after whole-body x irradiation was the same for both irradiated and control rats. However, the data on plasma $I^{131}$ fibrinogen indicate that fibrinogen leaves the vascular space at an enhanced rate after whole-body irradiation. (auth)

**31917** RADIOCHROMIUM-LABELED LYMPHOCYTES IN THE RAT. William L. Bunting, Joseph M. Kiely, and Charles A. Owen, Jr. (Mayo Clinic and Mayo Foundation, Rochester, Minn.). Proc. Soc. Exptl. Biol. Med., 113: 370-4(June 1963).

A technic is described for labeling rat lymphocytes, collected from intestinal lymph, with radiochromium without impairing their motility. After intravenous administration, these labeled cells disappeared rapidly from the circulating blood, reappeared to a limited extent within 6 hours, then continued to disappear at a very slow rate (about 1.1% per hour). When the rat's intestinal lymphatic trunk was cannulated, 4 to 7% of the labeled lymphocytes appeared in the lymph within 4 days, with maximal lymphatic radioactivity occurring between the 24th and 36th hours. (auth)

**31918** SENSITIVITY OF THOROTRAST-TREATED MONKEYS TO STAPHYLOCOCCAL ENTEROTOXIN. H. Sugiyama, E. M. McKissic, Jr., and M. S. Bergdoll (Univ. of Chicago). Proc. Soc. Exptl. Biol. Med., 113: 468-70(June 1963).

Monkeys pretreated with stabilized colloidal thorium dioxide (Thorotrast) are more sensitive to the emetic action of intragastrically administered staphylococcal enterotoxin. The amounts required to elicit vomiting in 50% of the animals tested was reduced to about one-twentieth of that required for untreated monkeys when Thorotrast was given 18 hours before the enterotoxin challenge. The degree of sensitization was the same for both of the 2 different antigenic types of enterotoxin tested. Fresh blood was observed in the vomitus when the interval between Thorotrast and enterotoxin was reduced to 4 hours. (auth)

**31919** INCREASE IN LYSOZYME ACTIVITY IN KIDNEYS OF IRRADIATION CHIMERAS. Vu-Thi Suu, C. C. Congdon, and A. L. Kretchmar (Oak Ridge National Lab., Tenn. and Oak Ridge Inst. of Nuclear Studies, Tenn.). Proc. Soc. Exptl. Biol. Med., 113: 481-5(June 1963).

Assay of lysozyme activity in homogenates of kidney of irradiation chimeras has shown that a marked increase in activity is associated with the presence of grafted homologous bone marrow. This increase began about 3 days after injection of the marrow cells, reached its peak 20 to 40 days and returned to normal 100 to 200 days after treatment. A significant increase in weight of kidney, maximal at 9 days after treatment, was observed in the animals given homologous bone-marrow cells. (auth)

**31920** COMPARISON OF THE PHYSICO-CHEMICAL AND PHYSIOLOGICAL BEHAVIOR OF NATURAL INULIN WITH ITS RADIOACTIVE DERIVATIVES. Philip S. Chen, Jr., A. Raymond Terepka, and Kea Lane (Univ. of Rochester, N. Y.). Proc. Soc. Exptl. Biol. Med., 113: 584-8 (July 1963).

In several in vitro systems it was found that the $C^{14}$ (inulin-$C^{14}OOH$) and $H^3$ (inulin-$OCH_3^3$) labelled derivatives behave differently from ordinary inulin. Several lots passed faster than inulin through cellophane tubing in dialysis or centrifugal-pressure ultrafiltration. Size differences were also demonstrated by gel filtration through Sephadex G-50 column. Migration of inulin-$C^{14}OOH$ from inulin occurred in paper electrophoresis because of its anionic nature. Following a single i.v. injection to a dog, urine $C^{14}$ specific activity was not higher than administered dose but fell with time, showing that the glomerular capillaries did not restrict filtration of inulin as compared with the smaller inulin-$C^{14}OOH$. It is suggested that a more rapid rate of extrarenal removal of the radioactive inulin-$C^{14}OOH$ occurred. (auth)

**31921** SENSITIVITY OF IRRADIATED MICE TO BACTERIAL ENDOTOXIN. Willie W. Smith, Ilo M. Alderman, Carol Schneider, and Jerome Cornfield (National Cancer Inst. and National Heart Inst., Bethesda, Md.). Proc. Soc. Exptl. Biol. Med., 113: 778-81(July 1963).

Exposure to radiation, especially in the lethal range, caused a marked increase in sensitivity of mice to S. typhosa endotoxin. This was most pronounced on the third day after irradiation. At that time the endotoxin $LD_{50}$ in mice given 1000 rads was 0.5 μg compared to a control value of 480 μg per 20 g mouse. Shielding the hind legs was without effect on endotoxin $LD_{50}$ (2.3 μg for 850 r, 200 Kv x rays). Shielding the back, including the adrenals, was partially effective ($LD_{50}$, 55 μg). Treatment with cortisone had an effect comparable to that of shielding the back. Shielding the front of the animal, including practically all of the intestinal tract, was very effective in spite of the fact that the adrenals were irradiated ($LD_{50}$, 410 μg). Shielding a small portion of the abdomen was also quite effective in reducing endotoxin sensitivity in the irradiated mice ($LD_{50}$, 165 μg). (auth)

**31922** STUDY OF DNA RADIATION DAMAGE BY THE METHOD OF THERMAL STRAND SEPARATION. II. EFFECT OF IONIZING AND ULTRAVIOLET IRRADIATION ON SEPARATION OF 2-STRAND DNA. N. I. Ryabchenko, P. I. Tseitlin (Inst. of Experimental Biology and Medical Radiology, Moscow). Radiobiologiya, 3: 331-5(1963). (In Russian)

Preparations of DNA separated from calf thymus were irradiated with x and ultraviolet radiation, heated in 0.01 M $Na^+$ solution at different temperatures, and rapidly cooled. The x irradiation had no effect on separation of the strands. As in the case of the unirradiated preparations, the transition from a rigid 2-strand form to a pliable 1-strand form proceeded in jumps. Ultraviolet irradiation prevented the separation. EDTA in a concentration of 0.001 M had no protective effect against ultraviolet radiation since ultraviolet acts directly on DNA, but it protected the DNA from free radicals formed in the water during the irradiation. In both the presence and absence of EDTA in the x-irradiated DNA and in the unirradiated the increase in flexibility was spasmodic, while in the ultraviolet-irradiated DNA it was smooth. Data on the kinetics of the thermal separation of irradiated DNA indicated the appearance in the macromolecule of a denaturation-type disturbance. Earlier publications showed the two-stage nature of the DNA strand separation. (20 references) (TTT)

**31923** PHYSICO-CHEMICAL CHANGES IN DESOXYRIBONUCLEIC ACID BROUGHT ABOUT BY $Pu^{239}$ IN VIVO. V. V. Konstantinova. Radiobiologiya, 3: 336-40(1963). (In Russian)

Plutonium-239 nitrate was injected into rabbits, at the rate of 7 μcurie per kilogram, and three to six months later the animals were killed by air embolisms and the livers were examined for DNA. The average molecular weight of the DNA from the irradiated animals was $3.1-3.7 \times 10^6$, compared to $4.5 \times 10^6$ for that from the controls. The amount of DNA in the irradiated livers was 0.62–0.74 mg per gram of liver, about half that in the controls. The amount of plutonium in the DNA preparations averaged $5.1 \times 10^{-3}$ μcurie per 100 mg of dry DNA, which may be a low value because of the separation of plutonium during the DNA recovery process. A spectrophotometric titration of

DNA recovered from the controls and from three-month experimental animals showed no difference in the hydrogen bonding. Data on mole percentages of nucleotides and on nitrogen and phosphorus contents of the DNA preparations showed no difference in the nucleotide contents but 13% decrease in cytosine six months after plutonium administration. The change in molecular weight may be due to the direct action of DNA with alpha particles of the plutonium or with radicals formed, which could rupture the phosphodiester bond and thus decrease the degree of polymerization and increase the activity of desoxyribonuclease. The decrease in cytosine could be due to deamination and conversion to uracil. (TTT)

**31924** CHANGES IN SORPTION PROPERTIES OF SOME CELLS AND TISSUES IN WHOLE-BODY X-IRRADIATED WHITE MICE. G. N. Kuz'minskaya (Research Inst. of Hygiene, Leningrad). Radiobiologiya, 3: 341-4(1963). (In Russian)

The sorption capacity for and granule formation with vital dyes of tissues of white mice after 900 roentgens whole-body x irradiation were studied. Granule formation was studied in blood samples taken from the living animals at various times, after which the animals were sacrificed and tissues were taken for sorption studies. Times varied from one to six days after irradiation. In the radiation-sensitive iliac lymph node and spleen tissue, sorption of phenol red was several times higher than in the controls, reaching a maximum of four- to five-fold the third day after irradiation. Changes in sorption of the radiation-sensitive testis and radiation-resistant gastrocnemius muscle were insignificant. However, since there was a slight change in the testis on the fifth and six days, longer observation may have shown a significant change here. The total number of erythrocytes did not change, but the number that took up neutral red decreased 15-fold the first day, then practically disappeared, and reappeared only on the sixth day. The number of reticulocytes decreased two-fold the first day, and then also gradually disappeared but reappeared on the sixth day. This is in agreement with published in vitro work. (TTT)

**31925** EFFECT OF RADIOACTIVE PHOSPHORUS ON MINERAL AND PROTEIN METABOLISM IN CALCIFYING TISSUES. A. A. Prokhonchukov (Medical Stomatological Inst., Moscow). Radiobiologiya, 3: 345-50(1963). (In Russian)

Radioactive phosphorus was injected intraperitoneally to a strain of inbred rats as $Na_2HP^{32}O_4$ in physiological saline solution in doses of 0.5, 1, 2, and 4 μcuries per gram of body weight. Mineral and protein were traced with $Ca^{45}$ ($Ca^{45}Cl_2$) and $C^{14}$ (glycine-$C^{14}$). Radiation damage was determined from the leucocyte and erythrocyte contents of the blood. Animals were sacrificed at from two to ninety days after the $P^{32}$ was given and pathology studies were made on the calcifying tissues and internal organs of some of the animals. Four hundred and sixteen samples were studied, and the data were treated statistically. The nature and degree of the changes depended on the size of the dose of $P^{32}$. In doses of 0.5, 1, and 2 μcuries/g, $P^{32}$ increased the mineral and protein metabolic processes in calcifying tissue for the first twenty days after its administration and then decreased it. With a dose of 4 μcuries/g, the metabolic processes decreased after two days; the level of $Ca^{45}$ and $C^{14}$-labeled glycine decreased in comparison with those in the controls. The greatest change in the bones and the least in the teeth, and the change in protein metabolism was greater than that in the mineral. The changes are similar to those caused by external irradiation with x rays but are more stable. The changes precede the development of morphological changes in the tissues. Detailed tables of data and 28 references are given. (TTT)

**31926** EFFECT OF $Pu^{239}$ ON PHOSPHATASE ACTIVITY AND ON Ca, P, AND N CONTENTS OF BONE TISSUE IN RABBITS. N. I. Elkina. Radiobiologiya, 3: 351-4(1963). (In Russian)

Pathological processes occurring in bone tissue on entry of plutonium-239 were studied by determining the phosphatase activity and the content of several substances in tissues of 84 rabbits. Plutonium nitrate solution was given intravenously, at the rate of 7 and 2 μcurie/kg, and animals were sacrificed after 3 to 180 days for the first dose and after 135 to 360 days for the second. Controls showed a decrease in the alkaline phosphatase activity in the epiphysis to 54% and in the diaphysis to 45%. Acid phosphatase activity also decreased significantly. The amounts of Ca, P, and total N in the bones did not change statistically in either the controls or the animals given plutonium. However, in animals given 7 μcurie/kg plutonium, the alkaline phosphatase activity increased somewhat in 7 to 14 days after administration, but subsequently decreased and at 30 days was 70% of normal. Morphological observations indicated increased osteoblasts. After 90 and 135 days, the decrease in enzyme activity became clearer, and osteoblasts were significantly lower. After 180 days, alkaline phosphatase activity in the diaphysis was 61% of normal and in the epiphysis was 50%. After 30 days the acid phosphatase decreased to 37% in the diaphysis and to 29% in the epiphysis but did not change further. Morphological studies indicated high resorption with 2 μcuries/kg Pu. Alkaline phosphatase change were later, and only in the epiphysis, to 27% after 135 days. Osteoblasts increased, and the bone structure was atypical. (TTT)

**31927** FREE RADICALS IN LIPIDS OF THE LIVER AND SPLEEN OF IRRADIATED RATS. I. K. Kolomiitseva (Inst. of Biological Physics, Moscow). Radiobiologiya, 3: 359-63(1963). (In Russian)

Free radicals in the lipids extracted from the liver and spleen of irradiated rats by alcohol-ether were examined by the electron paramagnetic resonance method. The amount of free radicals in the preparations depended somewhat on the purity of the extractant, being highest when the reagent was distilled from $SnCl_2-H_2SO_4$. After a whole-body dose of 1000 r, the quantity of free radicals in the liver lipids 5 min after irradiation reached an average of 178% of that in the controls. This level was maintained to 24 hr, but at 48 hr reached 236%. Then, at 66 hr, it had dropped to 64%. The free radical content of the lipids from the spleen did not change after 5 min or 24 hr, but 48 hr after irradiation it had sharply increased. Data on synthesis of lipids show that the highest incorporation in lipids of tagged acetate occurs at 48 hr, and then there is a sharp drop in the rate of synthesis at three days. These results indicate a connection between lipid synthesis and free radical formation. The possibility is suggested that the substances detected here as free radicals are easily oxidized compounds which give up free electrons and are then converted to free radicals. (TTT)

**31928** THE IMPORTANCE OF CERTAIN TRACE ELEMENTS IN THE DEVELOPMENT OF RADIATION PATHOLOGY. I. K. Zyuzin. Radiobiologiya, 3: 364-8(1963). (In Russian)

In irradiated animals, Cu and Co increase in the blood and in many organs, apparently withdrawn from the liver depots. This may be considered a protective mechanism.

In the irradiated animal, highly toxic substances, free radicals, and peroxides, form and accumulate in the organism, resulting in a series of reactions in the animal. In the healthy organism the presence of natural antioxidants prevents such accumulation. When the oxygen content of the tissue is low, radical formation is less; the decrease in tissue respiration creates a tissue hypoxia, protecting the organism from radiation damage. Oxygen in the tissue is decreased by Cu, respiratory enzymes are suppressed, and hypoxia results. Histaminase activity is decreased, and the resulting increase in histamine increases the capillary wall permeability to plasma, edema results, oxygen supply to the tissue is interferred with, and hypoxia occurs. The hyaluronidase activity is also increased, with increased vessel permeability, hemorrhagic effects, lowering of the connective tissue barrier effects, and spread of toxic substances to the tissues. Tyrosinase activity is decreased, with formation of adrenalin. Morphological changes occur in various tissues. Fe is lowered in the liver, shortening erythrocyte life and decreasing antitoxic properties of lymph. The Co increase in the tissues lowers the hemoglobin capacity for oxygen, with resulting tissue hypoxia, increases catalase activity and causes other changes. Co combines with methionine, nicotinic acid, vitamins B-1 and B-12, but suppresses erythropoiesis and interferes with synthesis of RNA, cysteine, and choline and therefore disturbs phospholipid formation in the liver. (29 references) (TTT)

**31929** CHANGE IN SPERMATOGENESIS IN DOGS IN CHRONIC Sr-90 INJURY. L. N. Burykina and N. E. Trusova. Radiobiologiya, 3: 369-76(1963). (In Russian)

Lifetime studies were made of the functional state of the sex glands of animals chronically exposed to small doses of radioactive strontium. Spermatogenesis was studied in eight dogs, who were fed $Sr^{90}$, 0.2 or 0.02 μcurie/kg per day for 24 to 40 months. The studies were made by determining the ejaculation volume, total spermatozoa in the ejaculant, percentage of atypical forms, and activity of the spermatozoa. The general systemic condition of the dogs throughout the experiment is discussed, e.g., worsening of dispositions after two or three years, absence of significant weight changes, increased functioning of various organs and systems in the early part of the study. Changes in spermatogenesis were observed in 5 to 12 months and included fluctuations in the functional activity of the glands and increased number of atypical forms of spermatozoa. A persistent depression in spermatogenesis was observed 14 months after the experiment started. The disturbance in spermatogenesis developed earlier than that in the blood-producing system. Two or more years after cessation of administration of $Sr^{90}$, recovery of spermatogenesis was not noted. (TTT)

**31930** DEPENDENCE OF THE REACTION OF THE BLOOD SYSTEM OF DOGS ON THE ORIGINAL STATE OF THE BLOOD-FORMING ELEMENTS IN CHRONIC $Sr^{90}$ IRRADIATION. M. F. Aleksandrova and L. N. Selivanova. Radiobiologiya, 3: 383-8(1963). (In Russian)

Seven male dogs were fed $Sr^{90}$ in equilibrium with $Y^{90}$, 0.001 μcurie/g, for 320 days, with a tissue dose of 1.6–1.7 rad/day, totaling 400 rads. The dogs were divided into two groups, the bone marrow cells, erythroblasts and granulocytes being initially 1.5- to 2-fold higher in group two than in group one. The reaction of the two groups differed greatly. In the low-functional activity group the erythroblast activity after 10 months was 137% of normal although the erythroblasts in the peripheral blood averaged 10% higher. Reticulocytes decreased. In the group having an initially higher erythroblast level, the level decreased to 50% in a month and to 37% of normal in 5 months. There was no change in the blood stream. In group one the bone marrow granulocytes were about the same or slightly higher after 7 months and decreased to 35% after 10 months. But in group two there was a decrease to 35% after 1 month, a short period of granulopoiesis (3 months), and then a depression. The platelet level showed a clear tendency to decrease the first month and was 50% after 10 months. There was no great difference in the peripheral blood platelet content in the two groups. (TTT)

**31931** CONCERNING SOME REGULARITIES OF BONE MARROW DESTRUCTION IN GAMMA-IRRADIATED RATS. G. P. Gruzdev, M. I. Fedotova, and E. N. Shcherbova. Radiobiologiya, 3: 389-92(1963). (In Russian)

Male white rats (Wistar strain) were whole-body irradiated with 150-5000 r from a cobalt gamma source. The reaction to the irradiation shown by the bone marrow was in three phases. In the healthy rats the nuclear cellular elements in the femoral marrow were 100-125 million. After irradiation there was no change for the first 4 hr (first phase). In the next 2 to 3 hr (second phase) the number dropped sharply to 30–40% of normal for the 150-r dose, to 40–50% for 400 and 750 r, and to 50–60% for 5000 r. The third phase, which lasted until the level of the cells became stabilized, lasted different lengths of time for different irradiation doses, and was 11-12 hr for 150 r, the same for 400 r, 41-42 hr for 750 r, and 65-66 hr for 5000 r. Complete suppression of the regeneration processes, which was observed for 400-r doses and higher in unpublished data, was not observed for 150-r doses. The final curve of dose versus percentage of cells destroyed showed 52% destroyed for 150 r, 73% for 400 r, 94% for 750 r, and 99.1% for 5000 r. The degree of damage is determined by the symptoms of the second phase and the time increment of the third. Mathematical formulas are given for calculating the dependence. (TTT)

**31932** EFFECTS OF IONIZING RADIATION ON THE CONTENT AND METABOLISM OF NUCLEOTIDES IN RABBIT LYMPHOID TISSUE. I. A. Tseveleva. Radiobiologiya, 3: 393-9(1963). (In Russian)

Ionizing radiation is known to cause depression of synthesis and decrease in the amount of nucleic acid in tissues, especially in those of intensive metabolism, e.g., the appendix lymphoid tissue, bone marrow, and spleen. Experiments were made to determine the concentration of $P^{32}$ and the rate of its incorporation into nucleotides of the appendix lymphoid tissue of 102 (plus 30 control) rabbits at different times after irradiation with 1000 r. The $P^{32}$ was given intravenously as $Na_2HP^{32}O_4$ solution, 0.3 mC/g, 15 min before the animals were sacrificed, which was done 0.5 to 1, 4, 12, 24, and 48 hr after irradiation. The results showed a significant depression of incorporation of $P^{32}$ in the appendix lymphoid tissue. After 0.5 to 1 hr, the concentration of nucleoside polyphosphate decreased to 27 to 65%. During the next 2 hr the diphosphate decreased further. After 48 hr the content of these substances was 60 to 70% below normal. The amount of nucleoside triphosphate was lowest 12 hr after irradiation, 82 to 92% lower than in the controls. After 24 to 48 hr the triphosphate level increased somewhat, but remained approximately 60% below that in the unirradiated animals. After irradiation the concentration of nucleoside monophosphate was somewhat higher than normal. Irradiation resulted in decreasing the rate of recovery of both nucleoside mono- and poly-phosphate formation. The greatest lowering of the specific activity took place 4 hr after irradiation and was to 30 to 80%. After

48 hr the intensive inclusion of $P^{32}$ into most nucleotides was 12 to 56% lower than in the controls. (TTT)

**31933** DYNAMICS OF THE BIOELECTRIC ACTIVITY OF RABBIT BRAIN IN SHORT-WAVE ULTRAVIOLET IRRADIATION. T. S. Stepanova and D. M. Tyukov (Polenov Inst. of Neuro-Surgical Scientific Research and Radiation Hygiene, Leningrad). Radiobiologiya, 3: 400-7(1963). (In Russian)

A study was made to determine the brain bioelectric activity under the influence of ultraviolet irradiation, especially the reactions taking place directly in the irradiation process. Twenty rabbits were whole-body-irradiated with 1000 to 5000 $\mu w.min/cm^2$ for 10 min. There were changes in the electroencephalogram immediately and for a time after the irradiation. The most regular change was a decrease in the amplitude of the bioelectric activity. The phase of biopotential exaltation observed by others with penetrating radiation occurred only in direct irradiation of the exposed brain, and the decrease in the biopotential amplitude was less than that described. There was also an increase in the processes of distance synchronization in the electroencephalogram and a change in the frequency spectrum, although the latter was less definite. The data showed that irradiation at 5000 and 3800 $\mu w.min/cm^2$ caused a timely and reversible but significant change in the electroencephalogram, usually in all symptoms studied. With 2000 and 1000 $\mu w.min/cm^2$, these changes were not observed visually but were seen only with mathematical analysis. (TTT)

**31934** ROLE OF THE MIDBRAIN COVERING AND SUBTHALAMUS IN THE EARLY BIOELECTRIC REACTION OF THE RABBIT BRAIN CORTEX TO WHOLE-BODY IONIZING IRRADIATION. A. N. Lebedev (Inst. of Higher Nerve Action and Neurophysiology, Moscow). Radiobiologiya, 3: 408-14(1963). (In Russian)

With the objective of clarifying the manner in which the midbrain covering effects the reaction of the cortex as a result of irradiation, the reticular formation was destroyed in 5 rats and the subthalamus in 7. There were six unoperated controls. A definite similarity was observed in the radiation reaction of the cortex of the two operated groups, the development of an early bioelectric reaction in the cortex following 1000 r irradiation being similar. The general conditions of the animals changed greatly: breathing became infrequent, pulses became faster, motor activity decreased progressively, fur fell out, appetite disappeared, stools became liquid with blood, and weight declined. All animals died the first day after irradiation. Anatomically it has been shown that the path from the covering of the midbrain to the cortex is through the subthalamus. Therefore the path is most probably the same in the irradiated animal. Charts are given which show the electroencephalograms before and after irradiation, with electrocardiograms, light stimulation response, and breathing of animals of the two operated groups. (TTT)

**31935** RADIATION ANALYSIS OF CHROMOSOME DISCRETENESS IN THE AUTOREPRODUCTION PROCESS. B. N. Sidorov and N. N. Sokolov (Inst. of Biological Physics, Moscow). Radiobiologiya, 3: 415-9(1963). (In Russian)

For solving the question of the fate of different types of chromosome fragments formed in irradiation, the colchicine mitosis method, in which the cells do not separate, was used. Sprouts of Crepis capillaris, which has three pairs of very different chromosomes, were x-irradiated with 200 or 400 r and placed immediately in a 0.01% colchicine solution, and the metaphase was studied in aceto-carmine preparations. The more prolonged the contact with colchicine, the greater was polyploidy of the cells; e.g., with 400 r and fixation 16 hr after irradiation, tetraploid cells were present, after 24 hr octoploid, and after 32 hr, 16-ploid. Analysis of the data shows the absence in the cells of the expected amount of fragments in a few cases, 4 out of 345 after the first reproduction and 2 out of 51 after the second. This may indicate a difference in the rate of fragment formation after irradiation. However, in the polyploid cells resulting from the K mitosis, the absence of whole chromosomes was also noted, as was the loss of the discrete normal structure of chromosomes in the descendants of cells formed under the influence of colchicine, and not irradiated. The process of destruction is connected with the characteristics of the process of reconstruction of the nucleus in the telophase of the colchicine mitosis in which multinucleated cells result. In the subsequent interphase, lysis of some of the formed micronuclei takes place. It was concluded that any chromosome fragment down to microfragments is able to go through a normal nuclear cycle and autoreproduction to three full cycles. (TTT)

**31936** DEPENDENCE OF THE FREQUENCY OF OCCURRENCE OF RECESSIVE SEX-LINKED LETHAL MUTATIONS IN DROSOPHILA SPERMATOGENESIS ON THE FAST-NEUTRON DOSE. E. A. Abeleva and Yu. A. Lapkin (Inst. of Biological Physics, Moscow). Radiobiologiya, 3: 420-1(1963). (In Russian)

Experiments carried out to clarify the fast-neutron-dose dependence of the occurrence frequency of dominant lethal mutations were inconclusive. The difference between the frequencies in spermatids and sperm with neutron irradiation was less than in gamma and x irradiation. The dependence on dose in the range 1200-2400 rad tapered off, as in gamma irradiation, but the absolute frequency was so high that it was explained by the reaching of the limits of possible occurrence of the given type of mutation. To determine if hidden factors are involved or if the nature of the mutations caused by fast neutrons in spermatids is similar to that in low-ionizing radiation, the recessive sex-linked lethal mutations were studied, which are less frequent than the dominant. Comparison of the data obtained with earlier data showed that the ratios between the frequencies of mutation in spermatids and sperm in neutron-irradiation at 1000 rad are the same for 1000-r gamma radiation, that is, 2.27 and 2.16, respectively. In the 1000- to 2000-r range the frequency of mutation occurrence was proportional to the 0.57 power of the dose with gamma irradiation and to the 0.37 power with neutron irradiation. (TTT)

**31937** CHANGE IN THE ROENTGEN-RADIATION SENSITIVITY OF THE MICROSPORES OF TRADESCANTIA PALUDOSA IN THE COURSE OF MITOSIS. N. L. Delone (Inst. of Biophysics, Moscow). Radiobiologiya, 3: 422-6 (1963). (In Russian)

To calculate the number of chromosome rearrangements occurring in x irradiation during mitosis, microspores of Tradescantia paludosa, in which spontaneous rearrangements do not occur, were irradiated with 200 r. The sensitivity to radiation of the first postmeiotic phase was observed, and the rearrangements in the metaphases of the two subsequent mitoses were calculated. The relative sensitivity of the phases was established as: early interphase/late interphase/early prophase/late prophase/anaphase equals 1.0/1.1/1.8/5.5/6.1. The ratio of dicentrics to circulars in both early and late interphase was three, in early and late prophase was five, and in anaphase was eight. Therefore exchange between the arms in one chromosome takes place more often in interphase than in the

other phases, probably because of the long arms in this phase. In irradiation of the different phases the chromosome breaks as a single thread and in irradiation of the prophase the chromosome breaks as a double thread. Irradiation of the late prophase results in a polychromatid rearrangement in 1.2 percent of the cases which is of a type indicating a quaternary rupture. (TTT)

**31938** ACTION OF GAMMA RAYS, FAST NEUTRONS, AND ETHYLENIMINE ON THE VIABILITY OF AND CHROMOSOME ABERRATION IN POTATO SEEDS. N. D. Tarasenko (Inst. of Cytology and Genetics, Novosibirsk, USSR). Radiobiologiya, 3: 427-30(1963). (In Russian)

Gamma and fast-neutron irradiation of potato seeds increased viability, and ethylenimine decreased it 10% in comparison with controls. Germination was also increased by gamma irradiation but decreased by fast neutrons and ethylenimine. In the gamma irradiation, germination was maximum 6 days earlier, and with fast-neutron irradiation 4 days later than in the controls. Germination of all treated seeds was 7–12% lower than in the controls. In seedlings with three to five leaflets, after mutagen treatment the number of morphologically changed seedlings was high. In the middle of the vegetative period the number of seedlings with changed leaves and without a central growth point increased in the group irradiated with ionizing radiation. After gamma and fast-neutron irradiation, about one percent mutation was seen, with changes in the color, shape of the lobules, and pigmentation of the stem. The heights of the seedlings, weights of the tubers, and weights of the green mass of the plants varied considerably more in the mutagen-treated series than in the controls. The mutagen-treated seeds showed a significantly high percentage of mitoses with chromosome rearrangements. The gamma radiation dose was 15 kr, and the fast-neutron dose was 1000 rad; the ethylenimine was used in 0.1 percent aqueous solution. (TTT)

**31939** COMPARISON OF THE ACTION OF PROTECTIVE SUBSTANCES IN IRRADIATION OF MALIGNANT AND NORMAL TISSUE. N. I. Shapiro and E. N. Tolkacheva (Inst. of Biological Physics, Moscow). Radiobiologiya, 3: 431-9(1963). (In Russian)

In an attempt to discover whether normal and malignant tissue are affected differently by different chemical protectants, serotinin, meksamin (5-methoxytryptamine hydrochloride), cystamine, and diethyl stilbestrol were studied in mice and rats. Ascites and solid form of Ehrlich carcinoma and of Croker sarcoma (180) and rat sarcoma 45 were the abnormal tissues studied. Under the same conditions under which these substances protected normal tissue, they did not protect malignant tissue. When a substance was protective for abnormal tissue, its effectiveness was less than for normal tissue and was for a definite type of abnormal tissue: cystamine (0.15–0.5 mg/kg), the Ehrlich; AET (data from previous experiments, 0.3–0.4 mg/g), the Croker ascitic sarcoma; cystamine, serotinin (0.08 mg/g), and meksamin (0.08 mg/g), the Croker solid sarcoma; and serotin and meksamin, the rat sarcoma 45. The spectrum of action of the protectant changed as the conditions of use were changed. The difference in action in normal and abnormal tissues was in large measure determined by the distribution of the protectants in the animals with malignancies, and probably in these cases the concentration of the protectant in the tumor was lower than necessary for protection. (TTT)

**31940** IN VITRO STUDIES OF THE MECHANISM OF ACTION OF CHEMICAL PROTECTIVE SUBSTANCES. [PART] I. E. E. Ganassi, L. Kh. Eidus, and R. A. Arifulina (Inst. of Biological Physics, Moscow). Radiobiologiya, 3: 440-6(1963). (In Russian)

A systematic study of the protective action of substances of various types has been undertaken. Aqueous solutions of pepsin, 0.02 mg/ml ($6 \times 10^{-7}$ M) at pH 4.5–4.6, were irradiated at 370 r/min, and in one case at 700 r/min, by a $Co^{60}$ or $Cs^{137}$ gamma source, in the presence of $10^{-5}$ to $10^{-2}$ M protective substance (AET, sodium nembutal, cystamine, sodium metabisulfite, β-alanine). The degree of inactivation was determined by measuring the proteolytic activity. The dose curve was in two parts, indicating two fractions, the first being considerably more rapidly inactivated than the second. The fraction of the slowly inactivated part depended on the concentration of the protectant. AET and sodium nembutal at $4.5 \times 10^{-4}$ M concentration, cystamine at $3 \times 10^{-3}$ M, sodium metabisulfite at $1.4 \times 10^{-2}$ M, and β-alanine at $4.3 \times 10^{-2}$ M gave 10–80 percent protection. Analysis of the dose curves with different concentrations of protectants indicated a protection mechanism that includes blocking of part of the surface of the protein by the protective substance from the approach of oxygen, with which an oxygen-type damage could occur. (TTT)

**31941** EFFECT OF DIFFERENT DOSES OF SYNESTROL ON BLOOD FORMATION AND VIABILITY IN IRRADIATED BLACK MICE OF THE $C_{57}$ STRAIN. E. A. Pareishvili, E. E. Ogandzhanyan, and Yu. B. Kheifets (Radiobiological Inst., Erivan and Sechenova Medical Inst., Moscow). Radiobiologiya, 3: 447-52(1963). (In Russian)

Since the mechanism of the disturbance of blood formation in radiation sickness was not studied sufficiently, work was started to clarify the nature of radiation damage to the hematopoietic system on introduction of sex hormones. Male black mice of the $C_{57}$ strain, 52 controls and 73 experimental, were irradiated to 600 r. A single administration of 0.1 cc of 2 percent oil solution of synestrol (an estrogen) 7 days before irradiation increased the survival of the animals from 1.9 to 27.3 percent. Several administrations for a total of the same amount over a period of seven days before the irradiation did not show a positive effect on the survival or course of the sickness. Comparison of the peripheral blood in animals given the estrogen similarly and not irradiated with that of treated animals at various times after irradiation showed that a preliminary single administration of the estrogen did not prevent a sharp decrease in blood formation the first day of the radiation sickness. However, regeneration processes took place earlier and more intensively in the treated than in the controls. (TTT)

**31942** CYTOLOGICAL ANALYSIS OF THE ACTION OF HIGH-ENERGY PROTONS. II. EFFECT OF S, β-AMINOETHYLISOTHIURONIUM (AET) ON DESTRUCTION, MITOSIS, AND CHROMOSOME ABERRATION IN BONE MARROW OF MICE WHOLE-BODY IRRADIATED WITH 600-Mev PROTONS. S. P. Yarmonenko and N. L. Shmakova (Inst. of Occupational Diseases and Industrial Hygiene, Moscow). Radiobiologiya, 3: 453-5(1963). (In Russian)

Data are presented on bone marrow cells of mice irradiated with 660-Mev protons and protected with AET, which is known to protect (30 days survival) 87 percent of the animals from a lethal dose (1600 rad) of high-energy protons. White male mice were injected intraperitoneally with 3 mg of AET bromide 5 to 10 min before a 1000-rad irradiation. In the controls, 3 to 5 hr after irradiation the degenerating cells in the bone marrow were 8.5%; in the

protected animals they were 2.5 percent after 3 hr, and 4.4 percent after 5 hr. By the fourth day, or possibly earlier, there was no difference. The damaged cells were almost gone, and undamaged cell count was high. In the controls the first mitoses appeared 8 hr after irradiation, but in the protected animals they were seen in 3 hr and approached normal in 12 hr. The mitotic activity in the protected animals averaged twice as high as in the controls in the first 4 days. The largest number of chromosome aberrations were found 24 hr after irradiation, 90 percent in the controls and 60 percent in the protected. On the fourth day the percentages of cells with aberrations decreased in both the experimental and control animals, and on the tenth day were the same. (TTT)

**31943** DISTRIBUTION OF $S^{35}$ AMONG ORGANS AND TISSUES OF THE RAT AFTER INTRAPERITONEAL INJECTION OF RADIOACTIVE SULFUR-LABELED SULFUR-CONTAINING RADIATION-PROTECTIVE COMPOUNDS. E. G. Mikhailova (Kurov Military Medical Academy, Leningrad). Radiobiologiya, 3: 463-6(1963). (In Russian)

The distribution of sulfur-containing radiation-protective compounds and their conversion products is of interest in connection with the mechanisms of their action. Sulfur-35-labeled effective compounds, cystamine and beta-aminoethylisothyronine, and chemically similar ineffective compounds, disulfide-5-mercaptopentylamine and ethyl isothyronine, were studied. Ten rats were injected intraperitoneally with each compound, and five were sacrificed after 1 hr and the other five after 3 hr. Determinations of radioactivity in homogeneous suspensions of the organs showed nonuniform distribution of the compounds. With the protective compounds, the highest $S^{35}$ content was found in the radiosensitive tissues such as bone marrow, spleen, intestine, liver, and lungs, and in the excretory organs such as the kidneys. The smallest amount was in the blood, muscle, and brain. The ineffective compounds were distributed somewhat similarly. However, the amount in the radiosensitive tissues was smaller or was removed from them slowly. The conversion of ethyl isothyronine to a volatile compound, ethyl mercaptan, may explain its nonaccumulation in the kidney. (TTT)

**31944** EFFECT OF SOME PROTECTIVE SUBSTANCES ON GAMMA IRRADIATED CULTURES OF ZINOMOLGUS MONKEY HEART. I. M. Parkhomenko (Moscow State Univ.). Radiobiologiya, 3: 467-71(1963). (In Russian)

The protective action of propyl gallate, vinyl pyrrolidone, and the combined action of aminoethylisothiuronium. HBr and propyl gallate was studied for irradiation doses of 250 to 850 r. Survival of cells treated with 30 and 60 μg/ml of propyl gallate before irradiation with 550 r increased from 46 to 75%. Survival was greatest when the agent was introduced 5 min before irradiation and approached the unprotected value when it was introduced 30 min before. Survival of cells treated after irradiation decreased to 20 and 35%, respectively, but increased to 71% with 10 to 20 μg/ml in 30 min treatment and then decreased to 41% in 60 min. Survival of cells irradiated in the presence of 0.5, 0.75, and 1% vinyl pyrrolidone increased to 53, 66, and 72%, and the time effect was similar to that with propyl gallate. Treatment after irradiation with 1% decreased survival to 8% but 0.3% vinyl pyrrolidone increased survival to 57%. Treatment with AET before irradiation and with propyl gallate afterwards resulted in 80% survival. Since the protective action of vinyl pyrrolidone is caused by radiation grafting instead of radical formation, this is further evidence of the role of radical formation in the mechanism of radiation injury. (TTT)

**31945** FORMATION IN GAMMA-IRRADIATED POTATO TUBERS OF SUBSTANCES THAT DEPRESS PLANT GROWTH AND DEVELOPMENT. A. M. Kuzin and A. K. Kasymov (Inst. of Biological Physics, Moscow). Radiobiologiya, 3: 472-6(1963). (In Russian)

Polyphenyloxidase activity in potato tubers measured 24 hr after irradiation increased two-fold as the irradiation dose was increased from 10 to 50 kr. Doses of 1 to 10 kr had very little, if any, effect. There was no induction period of about 1 hr after irradiation before the polyphenyloxidase activity appeared. The growth of seeds of two types of maize and of pumpkins, peas, and beans soaked in extracts of the tubers receiving 25- and 50-kr doses was inhibited, as shown by the length and the dry weight of the stems and roots of the seedlings, as well as by visual observation. To prevent gradual darkening of the extract (melanin formation) on standing, which took place more rapidly in the case of the irradiated tubers than in the unirradiated control extracts, the extract was prepared at dry ice temperature in a carbon dioxide atmosphere. The seeds were coated with vaseline during the soaking to prevent oxidation effects. These results are of interest in relation to irradiation of potatoes to prevent sprouting during storage. (TTT)

**31946** STUDY OF THE FAST-NEUTRON EFFECT ON THE SPLEEN OF WHITE MICE BY A TISSUE-CULTURE METHOD. A. F. Ivanitskaya (Severtsov Animal Morphology Inst., Moscow). Radiobiologiya, 3: 477-82(1963). (In Russian)

The effect of a lethal irradiation dose, 600 rads, on the spleens of white mice was studied by means of tissue cultures. The reactor beam used for irradiation was a mixture of fast neutrons and gamma rays. The animals survived 3.1 days, and spleens were removed on the day of irradiation and 1, 2, and 3 days afterwards and were observed in the culture for 4 to 7 days. Lymphoid cells of the excised spleens of irradiated animals were characterized by shortening of their life to 3 to 4 days, decreased motility, appearance of binuclear forms; in the growth zones of spleens removed 3 days after irradiation there were single cells or groups. Granulocytes were very mobile, moving from the excised spleen to the medium; they disappeared after 4 days. Immature granulocytes were seen in spleens excised the day after irradiation but not in later excised ones. There were fewer migrating granulocytes in later excised ones. The granulocyte life decreased from 5 to 3 to 4 days. Stroma cells were not uniform and consisted of cells of the fibrotic type of capsule and trabecule, of the ordinary reticular stroma type, free cells of the macrophage type, and cells of the vascular endothelium. Polynuclear cells and mitoses were found regardless of the time of excision, mitoses reaching a maximum in the third to fifth day of culture but always being less than controls. Results are compared with those of many other workers. (21 references). (TTT)

**31947** CORN SEEDS AFFECTED BY HEAVY COSMIC RAY PARTICLES. Howard J. Curtis and Harold H. Smith (Brookhaven National Lab., Upton, N. Y.). Science, 141: 158-60(July 12, 1963).

Corn seeds of a special genetic stock were recovered from two satellite flights and the plants grown from them were examined for abnormalities. Some evidence for a slight increase in chromosomal deletions was observed, which was predicted from the flux of heavy cosmic ray primary particles. Nothing unexpected was observed. (auth)

**31948** RADIOPROTECTION BY PRESSOR AMIDINES. William E. Rothe, Marie M. Grenan, and Shirley M. Wilson

(Walter Reed Army Inst. of Research, Washington, D. C.). Science, 141: 160(July 12, 1963).

Studies were made on the effects of pressor amidines and pharmacologically related amines on the radiosensitivity of mice exposed to about 100 r/min. The results showed that S-ethylisothiuronium is radioprotective when used over a wide dose range and for a considerable period of time. Also, papaverine, a known pharmacological antagonist significantly reduced the protective effect of a massive dose of S-ethylisothiuronium. It is suggested that pressor amidines offer radioprotective activity through a pharmacological mechanism, which leads to a lowered oxygen tension of radiosensitive tissues. (P.C.H.)

**31949** RELATIONSHIP BETWEEN NUCLEAR VOLUMES, CHROMOSOME NUMBERS, AND RELATIVE RADIOSENSITIVITIES. Arnold H. Sparrow, Lloyd A. Schairer, and Rhoda C. Sparrow (Brookhaven National Lab., Upton, N. Y.). Science, 141: 163-6(July 12, 1963). (BNL-6999)

An inverse relation between a volume estimated to be associated with interphase chromosomes and acute lethal exposure to x or $\gamma$ radiation was found in 16 plant species. The apparent differences in radiosensitivities found would seem spurious, since the estimated average energy absorbed in the nucleus per chromosome ($3.6 \times 10^8$ ev) approaches a constant (variation less than fourfold) in spite of wide ranges of lethal exposures (0.6 to 75 kr), of nuclear volumes (43 to 1758 $\mu^3$), and of somatic chromosome numbers (6 to 136). The regression line obtained can be used to predict the radiosensitivities of other plant species if their nuclear volumes and chromosome numbers are known. (auth)

**31950** EFFECT OF VARIOUS DOSES OF $\gamma$-RADIATION ON CHROMOSOMAL REARRANGEMENTS IN SPERMATOGENESIS OF THE MONKEY MACACA MULATTA. Chia-cheng T'an, Tsu-t'ung Liu, Chung-ju Chang, Hsing-fang Ch'iu, Chao-tsu Lei, and Ching-lun Hsueh. Shih Yen Sheng Wu Hsueh Pao, 7: 386-97(1962).

The testicles of nine monkeys were submitted to the effect of $Co^{60}$ $\gamma$ rays in doses of 5 to 400 r. One testicle of each pair was kept for control. Statistical treatment of the material showed that doses of less than 50 r do not increase the frequency of the chromosomal changes (FCC) in comparison with the control. At 50 to 400 r an exponential dependence of the FCC on the dose was observed. It must be stressed that the observed FCC were remarkedly less than those previously obtained using corresponding doses of x rays on monkeys of the same kind. (TCO)

**31951** INTERRELATION OF OXYGEN, WATER AND TEMPERATURE IN THE PRODUCTION OF RADIATION-INDUCED GENETIC EFFECTS IN PLANTS. R. A. Nilan, C. F. Konzak, J. R. Harle, and R. E. Heiner (Washington State Univ., Pullman). Strahlentherapie, Sonderbaende, 51: 171-81(1962). (In English)

Advantages of the use of plant seeds as a system for radiobiological research are pointed out. Techniques for experimental control of oxygen, water, and temperature before, during, and after seed irradiation are summarized. Results of studies of the effects of these environmental factors on genetic damage in plant tissues are reviewed. Evidence that under certain treatment conditions the induction of chromosome aberrations and mutations may not be correlated effects is presented. It is concluded that present knowledge of the interrelation of oxygen, water, and temperature in production of radiation damage in seeds permits considerable control over the biological effects of radiation. (A.G.W.)

**31952** A STUDY OF EARLY RADIATION EFFECT BY REGISTRATION OF CHANGES IN INTENSITY OF THE SECOND FLUORESCENCE OF LYMPHOCYTES. R. I. Pinto (Inst. of Cytology, Leningrad). Tsitologiya, 5: 295-302(May-June 1963).

In vitro irradiation of lymphocytes of the peripheral blood of mice produced changes in the second fluorescence of lymphocytes during the first hours after irradiation; therefore, the method may be used to study the early radiation effects. Definite mechanisms in changes of fluorescence intensity of irradiated cells were evident during the development of radiation injury, and a ratio between radiation effect and radiation dose was established. A relation between the magnitude of radiation effect and the intensity of fluorescence before irradiation, the original functional level of lymphocytes, was established. (OTS)

**31953** A STUDY OF CERTAIN FACTORS OF HEMOAGGLUTINATION AND COAGULATION AFTER THE IRRADIATION OF DOGS. J. Arendarcik and L. Itze. Vet. Casopis, 11: 485-93(1962).

Two groups of dogs were subjected to whole-body irradiation (100 and 300 rad) and one group was subjected to partial irradiation of the hepatic area only (600 rad) by $\gamma$ rays. Changes found were decreased activity of convertin, shortened time of recalcification, slight decrease in the activity of prothrombin, proaccelerin, and of the complex of prothrombin and fibrinogen. Radiosensitivity of the proconvertin was increased. Blood serum protein content was significantly decreased on the 4th day after irradiation by large doses. The albumin content was significantly decreased on the 4th day after irradiating the hepatic region, but the alpha-globulin content was increased. Hematocrit index and hemoglobin concentration were diminished. It was concluded that the proconvertin decrease may serve as a diagnostic symptom. (TCO)

**31954** THE EFFECT OF REPEATED SMALL DOSES OF X-RAYS ON THE PERIPHERAL BLOOD OF CHICKS DURING THE SIMULTANEOUS ADMINISTRATION OF HEMOPLASTIC SUBSTANCES AND OXYTETRACYCLINES. Vet. Med. (Prague), 7: 777-84(1962).

Changes in the red blood of chicks became evident after whole-body irradiation by a dose as small as 1 r. Macrocytosis became evident in the irradiated group during the initial period. In the white blood the number of lymphocytes was especially depressed and was the only cause of leucopenia. Tetracycline in combination with folic acid and vitamin $B_{12}$ exerted a negative effect on the number of lymphocytes. Total plasma protein content was slightly increased after a temporary fall. A delayed compensatory effect was noted after the use of the complex preparations. The latter also inhibited gamma-globulin transformation. (Referativnyy Zhurnal, Biologicheskaya Khimiya, No. 8, 1962)

**31955** THE CONDITION OF NUCLEIC METABOLISM IN ORGANS AND BLOOD OF CHICKENS AFTER WHOLE-BODY ROENTGEN IRRADIATION. G. P. Trefilov. p.92-4 of "Collection Material of 11th Scientific Conference of Leningrad Veterinary Institute, Leningrad, 1962."

The level of DNA, RNA, and nucleoproteins in the spleen, mucous membrane of small intestine, thymus gland, and blood formed elements of chickens 6 to 48 hr after x irradiation by 800 r doses was investigated. The DNA and nucleoprotein content in the organs and tissues was decreased after x irradiation, but the RNA content was increased. (Referativnyy Zhurnal, Biologicheskaya Khimiya, No. 10, May 1963)

**31956** RADIATSIYA I KAIMICHESKAYA ZASHCHITA. (Radiation and Chemical Protection). E. F. Romantsev. Moscow, Gosatomizdat, 1963. 207p.

Protection of organisms against ionizing radiation is discussed, and rational prophylactic measures are analyzed. The initial physico-chemical processes induced by exposure and their reactions to protective measures are studied considering amino acids, glutathiones, and mercaptoethylamine and its derivatives. Amines without SH groups, sodium nitrates, methylene blue, and vitamins are also discussed. (R.V.J.)

**31957** ABSORPTION OF $NaI^{131}$ THROUGH RAT SKIN AFTER X-IRRADIATION. G. Th. Wurdack. Thesis, Cologne, Universität, 1962. 43p. $2.00.

Irradiation of male rats with 400 to 2000 r x rays results in a marked delay of absorption. After irradiation with 10,000 r an increase of absorption could be observed. (Gmelin Inst.)

**31958** CHROMOSOME ABERRATIONS IN LIVER CELLS IN RELATION TO AGEING. H. J. Curtis and Cathryn Crowley (Brookhaven National Lab., Upton, N. Y.). p.251-8 of "Cellular Basis and Aetiology of Late Somatic Effects of Ionizing Radiation." New York, Academic Press, 1962. (BNL-6036)

The percentage of chromosomal aberrations present in regenerating liver cells of mice has been scored as a function of age in normal animals, time following neutron irradiation, and age of animals subjected to chronic $\gamma$ irradiation at 7-5 r/day. It is found that aberrations are very high in neutron-treated animals and even increase to nearly 90% in succeeding months. With chronic $\gamma$ irradiation the frequency increases somewhat faster than that of the controls, but not fast enough to be explained on the basis of a single hit phenomenon. It is concluded that there is chromosome healing following x or $\gamma$ irradiation. (auth)

**31959** STUDIES OF THE LABILE PHASE OF THE RADIATION EFFECT USING THE RADIATION-INDUCED INHIBITION OF GLYCOLYSIS OF THE EHRLICH-ASCITES CARCINOMA. K. Jacob. Thesis, Hamburg, Universität, 1962. 40p. $2.00.

Radiation-induced inhibition of anaerobic glycolysis in tumor cells is increased when oxygen is present during irradiation. The influence of temperature was measured. Decreased temperature results in an enhanced inhibition. After irradiation with 30 kr, the quotient of glycolysis of cells irradiated in the presence of oxygen to those without oxygen is 1:12. Treatment of anaerobic tumor cells with oxygen after irradiation results in an increase of glycolysis. This effect is explained by a labile phase of the radiation effect immediately after irradiation. The effects of oxygen on Ehrlich-ascites carcinoma of mice during and after irradiation are discussed. (Gmelin Inst.)

**31960** EFFECTS OF IRRADIATION ON ENZYMES IN E. COLI. 3p. (CONF-19-3)

From 2nd International Congress of Radiation Research, Harrogate, Eng., Aug. 1962.

To determine the effects of irradiation on enzymes in Escherichia coli strain Crookes, the influence of x radiation on the content of the coenzyme pyridoxal phosphate was investigated. The method of pyridoxal phosphate assay used was based on the fact that E. coli is able to produce tryptophanase. Enzyme activity was measured by determination of indole produced from tryptophane. Doses of 10,000 and 80,000 r of x radiation were given to resting cells and growing cells. It was found that pyridoxal phosphate production and content were not influenced by irradiation. (H.M.G.)

**31961** FACTORS AFFECTING THE "IN VITRO" INACTIVATION OF ALDOLASE BY X-RAYS. M. Quintiliani and M. Boccacci (Istituto Superiore di Sanita, Rome). 17p. (CONF-19-4)

From Second International Congress of Radiation Research, Harrogate, Yorkshire, Eng., Aug. 1962.

The influence of urea and of various protective compounds on the in vitro inactivation of aldolase by x rays was studied. Low concentrations of urea protect the enzyme from the inactivation, whereas high concentrations, able to induce an unfolding of the protein molecule, increase the degree inactivation by a given dose of radiation. Cysteamine, cystamine, aminoethyl-isothio-uronium, and glutathione, all protect the aldolase in solution from the inactivation by x rays. Cystamine is as protective as cysteamine, in equimolecular concentrations, when high inactivation levels are reached. No protection can be demonstrated when the aldolase, after incubation with the tested compounds, is precipitated and redissolved in a new medium before irradiation. Nevertheless, with $S^{35}$-labeled cystamine, it can be demonstrated that at least seven residues of cysteamine are bound to each aldolase molecule. The protective power of glutathione is reduced by a factor of about 0.2 in the presence of 4 M urea. The possible implications of these findings are discussed. (auth)

## Radiation Sickness

**31962** (DPSPU-63-30-5) MONITORING, DECONTAMINATION AND BIO-ASSAY OF A PLUTONIUM-CONTAMINATED INJURY. P. B. Vernon, R. M. Hall, and G. A. Poda (Du Pont de Nemours (E. I.) & Co. Savannah River Plant, Aiken, S. C.). May 1963. Contract AT (07-2)-1. 15p. (CONF-67-8)

From Health Physics Society Meeting, New York, June 1963.

A plutonium-contaminated puncture wound sustained in a processing facility necessitated extensive monitoring and bio-assay surveillance to determine the extent of plutonium deposition and the effectiveness of decontamination measures. A general description of the wound incident, the monitoring techniques used, a tabulation of decontamination and bio-assay data, and suggestions for future consideration are presented. (auth)

**31963** (JPRS-20282(p.17-26)) TREATMENT OF ACUTE RADIATION SICKNESS BY FRESH BONE MARROW AND BONE MARROW PRESERVED AT LOW TEMPERATURE (–196°C). N. S. Pushkar'. Translated from Probl. Gematol. i Pereliv. Krovi, 8: 47-51(Apr. 1963). 12p. (OTS-63-31346)

Studies in rats show that hemopoietic tissue preserved at –196°C retains its viability and can be used in the treatment of acute radiation sickness with results as good as those obtained with fresh bone marrow. (C.H.)

**31964** (JPRS-20469) ON THE POSSIBILITY OF THE USE OF SODIUM LACTATE IN RADIATION SICKNESS. L. B. Pinchuk. Translated from Probl. Gematol. i Pereliv. Krovi, 8: No. 6, 54(June 1963). 1p. (OTS-63-31439)

The administration of a 10% solution of sodium lactate had no therapeutic effect on radiation sickness in rabbits. (C.H.)

**31965** RADIATION PNEUMONITIS. J. Chandler Smith (Western Reserve Univ., Cleveland). Am. Rev. Respirat. Diseases, 87: 647-55(May 1963). (TID-16983)

From a review of the literature, it may be concluded that, since the recognition of radiation pneumonitis in 1922, the clinical features of this condition have been clarified, the radiographic patterns have been defined, the pathologic lesions have been described, and the effects of treatment have been appraised. In addition, the incidence has been revealed and the cause has been considered. Although knowledge has been advanced by these endeavors, two important points remain obscure: why some patients develop radiation pneumonitis while others do not; and why in some patients the disease process subsides spontaneously while in others the condition progresses relentlessly. (auth)

**31966** AN ANALYSIS OF THE EFFECT OF CHEMICAL ANTIRADIATION PREPARATIONS. S. P. Yarmonenko (Inst. of Industrial Hygiene and Occupational Diseases, USSR). Med. Radiol., 8: No. 6, 32-42(June 1963). (In Russian)

In experiments on mice subjected to whole-body single or fractional $Co^{60}$ gamma-irradiation, the relation between the quantity of antiradiation agents (cystamine, cysteamine, AET, 5-methoxytryptamine), radiation dose, and protective effect was investigated. It was found that no direct quantitative correlations exist between the content of the preparation in the organism and the value of the absorbed dose. Administration of half of the optimal protective dose is attended by a decrease of the protective effect, whereas in reduction of the quantity of the preparation down to $\frac{1}{3}$ of the optimal dose it disappears completely (the irradiation dose decreased correspondingly). The results of the investigations contradict the antiradical mechanism of action of the preparations and testify to the importance of conducting a detailed study of pharmacodynamic effects on the cellular level. (auth)

**31967** POTENTIOMETRIC DETERMINATION OF THE EFFICACY OF THE PROTECTIVE ACTION OF CYSTEAMINE ON MICE. G. V. Sumarukov and Yu. B. Kudryashov (Moscow State Univ.). Med. Radiol., 8: 42-4(June 1963). (In Russian)

During x irradiation of mice, a direct relation between the protective effect of cysteamine and the degree of changes in the level of the redox potential of a mouse muscle measured in vivo was revealed. The protective action of cysteamine was most pronounced one hour after intraperitoneal injection. At this time the redox potential of tissues shows the greatest reduction. The protective effect of cysteamine is noted during the first four hours following its administration into the organism. During this period there is seen the greatest decline of the redox potential in comparison with normal values. (auth)

**31968** THE EFFECT OF UNITHIOLE ON THE RENAL FUNCTION OF DOGS AFFECTED WITH IONIZING RADIATION. Z. I. Poluboyarinova. Med. Radiol., 8: No. 6, 44-50(June 1963). (In Russian)

Investigations established that the employment of unithiole in $Po^{210}$ affection of animals increases the life expectation and retards the development of renal function disorders at the early periods of radiation sickness. However, under the influence of unithiole the more prolonged accumulation of the radioactive substance in the kidneys leads to a severer affection of the latter with transition into nephrosclerosis. In experiments staged on intact animals the use of unithiole during the first 4–5 days causes an inhibition of diuresis and only in the subsequent days–polyuria. The changes are associated with the biphasic action of unithiole on the acid-base metabolism and function of the kidneys (renal blood circulation, glomerular filtration, canalicular reabsorption). (auth)

**31969** TRANSFORMATION OF HEMOPOIETIC CELLS OF TRANSPLANTED ALLOGENOUS BONE MARROW INTO IMMUNOLOGICALLY COMPETENT CELLS IN IRRADIATED DOGS. I. L. Chertkov, M. N. Novikova, L. S. Rogacheva, L. L. Shepshelevich, A. S. Maksimenko, and M. O. Raushenbakh (Inst. of Hematology and Blood Transfusion, USSR). Med. Radiol., 8: No. 6, 51-60(June 1963). (In Russian)

In experiments on dogs subjected to superlethal irradiation (1000 r), it was demonstrated that allogenous bone marrow transplantation does not produce a therapeutic effect, inasmuch as normal hemopoiesis of the transplant is preserved only for 3–4 days. Starting from the 5th–6th day there takes place transformation of hemopoietic cells into immunologically competent cells, which are the morphological basis of the transplant against host reaction. Transformation of hemopoietic cells (hemocytoblasts) into immunologically competent cells (lymphocytes) occurs via a number of transitional hyperbasophilic forms of the type of peculiar hemocytoblast, lymphoblast, and prolymphocyte. The transformation of hemopoiesis is associated with the antigenic differences of the donor and recipient, since during repopulation of the bone marrow from the screened extremities in active proliferation no hyperbasophilic cells are formed and the myeloid hemopoiesis is preserved. The formation therefrom of hyperbasophilic cells and lymphocytes is due to transformation of hemocytoblasts and not immunologically competent cells of the bone marrow, for this process was not as marked during transplantation of a suspension of lymphoid cells from the lymph nodes and spleen. (auth)

**31970** THE MECHANISM OF THERAPEUTIC ACTION OF BONE MARROW TRANSFUSIONS IN THE TREATMENT OF RADIATION SICKNESS. M. P. Bogoyavlenskaya, E. A. Zotikov, A. V. Ilyukhin, G. I. Kozinets, L. I. Krasyukova, and I. B. Gurevich (Inst. of Hematology and Blood Transfusion, USSR). Med. Radiol., 8: No. 6, 63-8(June 1963). (In Russian)

Experimental and clinical data demonstrating that the effect of bone marrow in chronic radiation injury is of biphase nature is presented. In the first phase an inhibition of hematopoiesis is noted, whereas in the subsequent period there is seen a rather intensive and stable stimulation (second phase). It was observed that the stimulating effect of bone marrow becomes manifest during the period of disappearance of its cellular elements from the blood of recipients, or 5–10 days after the injection. (P.C.H.)

**31971** EFFECTS OF HOMOLOGICAL BONE MARROW TRANSPLANTATION ON THE REACTIVITY INDICES AND SURVIVAL OF RATS EXPOSED TO LETHAL DOSES. I. G. Veksler (Ukrainian Inst. of Experimental and Clinical Oncology, USSR). Med. Radiol., 8: No. 6, 68-73(June 1963). (In Russian)

Multiple intravenous transplantation of homologous bone marrow retarded the course of radiation sickness and inhibited for 30 days the lethal effects of radiation in 35% of rats exposed to 650r. The transplantation stimulated normalization of morphological blood content and restoration of damaged leukocytes. The bone marrow transplantation also stimulated the cancerolytic activity of blood serum ordinarily completely inhibited during acute radiation sickness. (tr-auth)

**31972** DYNAMICS OF THE CHANGE IN THE AMOUNT OF INJECTED GAMMA GLOBULIN IN RABBIT BLOOD SERUM IN RADIATION SICKNESS. V. F. Sosova. Radiobiologiya, 3: 355-8(1963). (In Russian)

In the absence of information in the literature on the use of gamma globulin in radiation sickness, experiments were carried out on injected, irradiated animals. Into 22 rabbits totally irradiated with 800 r ($LD_{30/30}$), gamma globulin was injected intramuscularly in doses of 100 or 50 mg/kg 5 min before irradiation and of 25 mg/kg injected 3 days before irradiation and 3 to 5 days afterwards. Blood samples were taken at intervals and tested by the formalin agglutination test. Homologous gamma globulin did not undergo any appreciable changes in the irradiated organism. Probably because of the colloidal nature of the solution, the gamma globulin entered the blood slowly from the place of injection, reaching a maximum only after 2 to 7 days. The maximum was reached on the seventh day in the animals injected approximately simultaneously with irradiation or 3 to 5 days after. In those injected 3 days before irradiation the level was falling on the seventh day. The gradual decrease lasted more than 30 days for a dose of 25 mg/kg and more than 60 days for 50 and 100 mg/kg. In electrophoretic studies the serums of irradiated rabbits were shown to contain a relatively high alpha globulin and somewhat lower albumin than normal, but there was no regular decrease in the gamma globulin or increase in beta. Injection of gamma did not markedly change the serum protein fractions separated electrophoretically on paper. (TTT)

**31973** ON THE MECHANISM OF THE THERAPEUTIC ACTION OF HIGHLY POLYMERIZED DNA IN RADIATION SICKNESS. R. E. Libinzon, V. V. Konstantinova, T. G. Popova, and S. A. Rogacheva. Radiobiologiya, 3: 456-62 (1963). (In Russian)

To clarify the mechanism of action of highly polymerized DNA in acute radiation sickness, the fate of administered compounds in the normal and irradiated animals was studied directly, together with the effect of DNA on proliferation processes in bone marrow of irradiated animals. Fifty-five rats (there were 25 controls) were irradiated with 1000-r doses from $Co^{60}$, injected intraabdominally 24 hr later with 5 to 6 mg of highly polymerized DNA as liver, spleen, or thymus preparation in physiological saline, and 6 to 72 hr later were sacrificed. Homogenates of tissues were separated into DNA, RNA, and acid-soluble fractions. The DNA preparations, marked with $P^{32}$, were obtained from young rats partially hepatectomized and given $NaHP^{32}O_4$. The labeled DNA specific activity was highest in the liver in the first 6 hr after administration, 115% in the controls and 173% in the irradiated; it fell to 6% in both at 24 hr, and then rose at 72 hr to 70 and 30%, respectively. Spleen and bone marrow curves were somewhat similar in shape. The highest DNA activity was in the bone marrow in normal animals and in the liver in irradiated ones, and in most cases was lower in the irradiated than in the controls. In the bone marrow of the treated animals the mitotic activity was higher than in those not treated, and there were more nucleated cells. (TTT)

**31974** THE REACTIVITY OF ANIMALS SUBJECTED TO THE EFFECT OF IONIZING RADIATION. Ye. I. Burshteyn, T. G. Mankus, and K. A. Shafrina. Sb. Nauchn. Tr. Tashkentsk. Gos. Med. Inst., No. 23, 54-62(1962).

The reaction of the blood-forming organs to the action of small doses of phenylhydrazine was less pronounced in animals suffering radiation sickness; control animals showed high reticulocytosis and a more intense leucocyte reaction. The Artyus-Sakharov phenomenon appeared at a later date and ran a more severe course in rabbits suffering from radiation sickness than in control animals. Studies of blood protein fractions during the development of Artyus-Sakharov phenomenon showed a fall in the albumin and a rise in the globulin content during the period of infiltrate development. The blood protein composition had a tendency to normalize during the period of necrosis development. Shifts in protein fractions were intensified during the period of necrosis in irradiated rabbits. The data indicate the disruption of the reactive capacities of an organism after suffering radiation sickness, even during the clinical health period, which may be linked to the presence of subsequent reactions. (Referativnyy Zhurnal, Biologicheskaya Khimiya, No. 6, 1963)

**31975** THE REACTION OF NITROGEN METABOLISM AFTER ENTERAL AND PARENTERAL ADMINISTRATION OF PEPTONE AND GLYCOCOLL TO ANIMALS DURING RADIATION SICKNESS. V. A. Shkapina. Tr. Smolensk. Med. Inst., No. 14, 195-207(1962).

The blood content of residual N and $NH_3$ during radiation injury rises and corresponds with the periods of radiation sickness. Peroral administration of peptone and of glycocoll induced a rise in blood residual N. After irradiation during the first and third periods of radiation sickness after peptone administration, and during the fourth period of radiation sickness after peptone and glycocoll administration, blood residual N was not increased but decreased. The peroral administration of glycocoll to healthy animals led to a fall in the blood ammonia level; the effect was much weaker in irradiated animals. Blood $NH_3$ concentration after glycocoll administration rose in some animals. Curves for residual N and for $NH_3$ retained their essential characteristics after the intravenous administration of peptone and glycocoll, and are similar to curves obtained after the peroral administration of these two substances. A month and a half after irradiation the blood N and $NH_3$ curves following intravenous administration of peptone were similar to corresponding curves in unirradiated animals. The nature of residual N and $NH_3$ curves was essentially unchanged after repeated irradiation (1000 r) and the intravenous administration of glycocoll to the animals. Control data on blood showed that the leucopenia and lymphopenia effect is much weaker in repeatedly irradiated rabbits than in animals exposed to a single irradiation dose. (Referativnyy Zhurnal, Biologicheskaya Khimiya, No. 8, 1963)

**31976** THERAPEUTIC EFFECT OF SODIUM CHLOROPHYLLIN ON RADIATION SICKNESS IN ANIMALS. V. I. Levshin. Uch. Zap., Pyatigorsk. Gos. Farmatsevt. Inst., No. 5, 345-9(1961).

Sodium chlorophyllin (0.5 and 0.05 mg/kg body weight, respectively) was administered to rabbits exposed to x radiation in a dose of 700 r once, and for a period of 12 days after their irradiation. Sixty-day and six-month observations established an increase in the longevity of the animals as compared with the longevity of the control group of rabbits. The intraperitoneal administration of Na chlorophyllin during the period of the development of radiation sickness led to the rapid restoration of the blood indices and body weight of the animals. The life of the animals was prolonged by the fractional administration of Na chlorophyllin after their exposure to x radiation in doses of 1000 r. Eleven of 12 dogs administered Na chlorophyllin for a period of 30 days after irradiation by doses of 500 r were alive on the 45th day (only 5 of the 12 control animals were alive). The therapeutic effect of

Na chlorophyllin was expressed in general health improvement, rapid restoration of the number of leucocytes to the initial level, and the restoration to normal of the blood indices and body weight of the animals. (Referativnyy Zhurnal, Farmakologiya i Toksikologiya, No. 7, April 1963)

**31977** THE EPIDEMIOLOGICAL SIGNIFICANCE OF A DISTURBANCE OF IMMUNITY DURING AFFECTION BY IONIZING RADIATIONS. V. M. Shilov. Veonno-Med. Zh., No. 11, 29-33(1962).

A decrease in the resistance of the organism to infection during radiation sickness occurred as a result of disturbance in cellular (a decrease in the phagocytic capability of the leucocytes and the cells of the reticulo-endothelial system) and humoral immunity (a decrease in the bactericidal properties of blood as a result of inactivation of properdin, a serum protein with bactericidal properties). The development of autoinfection in radiation sickness cannot be explained by the increase in the permeability of the mucosae, as these phenomena frequently do not correspond in time. Inborn immunity evidently remains essentially unchanged under the effect of radiation sickness. A disruption of artificial immunity was manifested by an almost complete cessation of antibody formation. A disruption of processes of immunogenesis occurred only when antigen was introduced into the organism after irradiation (vaccination performed after irradiation has an unfavorable effect on the course of radiation sickness). If radiation affects a process of immunogenesis already begun, almost no decrease in antibody elaboration is observed. The significance of the disruption in immunity consists of the fact that the infecting dose is decreased, and the proportion of clinically pronounced forms of the disease, which proceed with greater severity or atypically is increased, chronic processes that had proceeded in a latent form are exacerbated, and the significance of serological methods of diagnosis and allergic reactions are lost, which makes diagnosis difficult. Under these conditions, bacteriological diagnosis with the isolation of a pure culture is of basic significance. (TCO)

**31978** OPHTHALMOLOGICAL CHANGES IN A PATIENT WITH ACUTE RADIATION SICKNESS. E. S. Kotova. Vestn. Oftal'mol., No. 3, 37-9(May-June 1963).

The case history of a 33-yr-old female patient who was accidentally exposed to general external $\gamma$ radiation from $Co^{60}$ with an activity of 40 kg equiv of Ra is described. The radiation dose equaled 500 r on the head, 650 r on the chest and abdomen, 4000 r on the wrist, and 300 r on the feet. Symptoms of acute radiation sickness appeared within a few minutes and the patient felt pain in the stomach, burning in the left wrist, dizziness, and vomiting. Treatment consisted of severe blood letting, 750 to 550 ml, and blood transfusion of the same type of blood plus 10 ml serotonin. A total of 10 hemotransfusions, transfusion of leuco-erythro-thrombocyte mass, plasma, blood substitutes, and 0.5% novocain solution were made. Two bone marrow transplants were administered (the first consisted of 2,225,650,000 cells in 170 ml plasma, administered on the 6th day; and the second consisted of 2,235,130,000 cells in 225 ml plasma, administered on the 14th day). In addition, the patient received antibiotics of broad spectrum, vitamin therapy, desensitizing agents, vicasol, kefir, and fruit juices. Major changes were noted in the form of marked and prolonged fall of diastolic pressure in the central retinal artery and enlarged caliber of retinal arteries and veins. After 35 days, the patient started a period of convalescence, and by the 65th day the leucocyte number had risen to 4400, at which time she was discharged, and later returned to work. (OTS)

**31979** COMPARATIVE CHARACTERISTICS OF THE EFFECT OF FRACTIONATED TOTAL IRRADIATION BY GAMMA-RAYS FROM $Co^{60}$ AND X-RAYS ON THE ACTIVITY OF SUCCINODEHYDROGENASE AND CYTOCHROM-OXIDASE OF THE CENTRAL NERVOUS SYSTEM, SKELETAL MUSCLE, AND LIVER. M. Yu. Taits. p.173-5 of "Data of the First Congress of Belorussian Physiological Society, Minsk, Academy of Sciences, BSSR, 1962."

Rabbits were subjected to fractionated irradiation, once weekly, by $\gamma$ rays from $Co^{60}$ or x rays with a total dose of 1000 r, as a result of which chronic radiation sickness resulted. The increased activity of succinic dehydrogenase of the central nervous system was evident only after $\gamma$ irradiation, and attained its maximum by the 60th day after $\gamma$ irradiation. After x irradiation the activity of succinic dehydrogenase was increased only in the cerebellum on the 90th day to 115.3%. The activity of succinic dehydrogenase of the liver after $\gamma$ irradiation was statistically above that of the control series on the 30th, 60th, and 90th days; but after x irradiation it showed a tendency toward rise only on the 60th day. No essential differences were evident in succinic dehydrogenase activity of skeletal muscle in all experimental periods after irradiation by both types of rays. Changes in the activity of cytochrome oxidase of the central nervous system had a contradictory tendency to changes in succinic dehydrogenase activity. The most significant decrease in cytochrome oxidase activity appeared in cell structural elements precipitating from homogenates at 7500 g acceleration. It was concluded that disturbances arise in the actions of succinic dehydrogenase and cytochrome oxidase during the different periods of fractionated irradiation, and the disturbances play a major role in the disruption of tissue respiration that is observed during chronic radiation sickness. (Referativnyy Zhurnal, Biologicheskaya Khimiya, No. 8, 1963)

# CHEMISTRY

## General and Miscellaneous

*Refer also to abstracts 31795 and 31797.*

**31980** (CONF-37-4) SPECTRA AND DECAY TIMES OF THE LUMINESCENCES OBSERVED FROM CHELATED RARE EARTH IONS. J. J. Freeman and G. A. Crosby (New Mexico. Univ., Albuquerque). [Dec. 1962]. For Sandia Corp., Albuquerque, N. Mex. Contract [AT(29-1)-789]. 28p. (SCDC-3299)

From American Chemical Society Meeting, Dallas, Texas, December 1963.

Emission spectra and decay times of the benzoylacetonate, acetylacetonate, and dibenzoylmethide chelates of trivalent samarium, europium, terbium, and dysprosium are reported. The groups of spectral lines observed from these compounds in rigid organic glasses and excited by ultraviolet light are given probable J-J assignments. The luminescence decay curves are analyzed in terms of a two-step decay mechanism and a lower limit of $5 \times 10^5$ $sec^{-1}$ was established for the intramolecular energy transfer rate constant. The nature of the donor level in the energy transfer process is discussed. Further evidence for quenching of the 4f electronic excited states of chelated rare-earth ions by a vibronic mechanism is presented. (auth)

**31981** (UCRL-10882) UNDERDEVELOPED AREAS IN HIGH TEMPERATURE CHEMISTRY. Alan W. Searcy (California. Univ., Berkeley. Lawrence Radiation Lab.). June 21, 1963. Contract W-7405-eng-48. (CONF-135-1)

To be presented at International Symposium on High Temperature Technology, Asilomar, Calif., Sept. 1963.

Areas of high-temperature chemistry that are considered underdeveloped, gains that may result from study of these areas, and experimental approaches that may be appropriate to these areas of investigation are discussed. Topics covered include: composition studies, thermodynamics and reaction equilibria, and reaction kinetics. (M.C.G.)

**31982** AN IMPROVED TECHNIQUE FOR LABELLING SAND WITH $Au^{198}$. B. L. Campbell (Australian Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). Intern. J. Appl. Radiation Isotopes, 14: 286-7(July 1963). (In English)

A technique was developed for rapidly sorbing $Au^{198}$ onto sand, particularly coarse sand. The technique consists of silvering the sand by the Brashear process and then shaking the silvered sand with $Au^{198}$ solution. The percentage of $Au^{198}$ taken up from acid (pH 3) and alkaline ammonia (pH 8) solutions as a function of time was studied and found to reach a maximum of 90% after 2.5 hr at pH 3 and 86% after 1.5 hr at pH 8. The technique is applicable to both high and low specific activities, and activity loss by abrasion is small. (D.L.C.)

**31983** THE 1:2 LANTHANUM–THORON CHELATE. Satendra P. Sangal and Arun K. Dey (Univ. of Allahabad, India). Z. Anorg. Allgem. Chem., 322: 107-12(May 1963). (In English)

Studies on the composition and stability of the lanthanum–Thoron chelate by the spectrophotometric method are described. This red colored chelate has $\lambda_{max}$ at 515 mμ. The composition as determined by different methods is 1:2. The chelate is stable between pH 4.0 and 8.0. The values of log K as determined by two different methods are 9.92 ± 0.25 and 10.25 ± 0.2, respectively, at pH 5.5 and temperature 25°. (auth)

## Analytical Procedures

*Refer also to abstracts 32375 and 32382.*

**31984** (CONF-16-1) A DEVICE TO MEASURE THORIUM-228 AT NATURAL LEVELS. John B. Hursh and Arvin Lovaas (Rochester, N. Y. School of Medicine and Dentistry). [1962]. Contract AT(30-1)-2193. 16p.

From International Symposium on the Natural Radiation Environment, Houston, Texas, Apr. 1963.

A method for measuring $Th^{228}$ in concentrations found in natural materials is discussed. The method consists of measurement of the thoron gas generated by the 3.64-day half-life $Ra^{224}$ daughter of $Th^{228}$. A scintillation detector is used. The thoron is adsorbed on the surfaces of small activated-charcoal particles fixed by pressure adhesive to a steel plate which forms the floor of a 3-in. diameter by 1/8-in. deep space bounded on top by a ZnS-coated lucite plate. The face of a 3-in.-diameter photomultiplier tube is joined to the uncoated surface of the disk with silicone fluid. Holes in the chamber allow the gas to pass through it. Four types of rock samples were analyzed for $Th^{228}$ using this equipment to illustrate its uses. (M.C.G.)

**31985** (CONF-124-1) THE APPLICATION OF NUCLEAR TECHNIQUES IN COAL ANALYSIS. Troy C. Martin, Suresh C. Mathur, and Ira L. Morgan (Texas Nuclear Corp., Austin, Tex.). [nd]. Contract AT(40-1)-2980. 43p.

From Symposium on the Application of Advanced Technology to Coal Research, Lexington, Ky., June 1963.

It was determined that the carbon, oxygen, aluminum, and silicon content of coal samples can be determined fairly accurately by nuclear techniques. These results to date also indicate that it is not feasible to measure sulfur in coal by the particular nuclear means investigated in this study. However, work is continuing in this area and these results do not rule out an order-of-magnitude measurement under field-type conditions. The estimated accuracy with which these elements can be measured is listed. (auth)

**31986** (TID-19179) DETERMINATION OF ZIRCONIUM AND HAFNIUM IN METEORITES, SEDIMENTS, AND TERRESTRIAL MATERIALS BY NEUTRON ACTIVATION ANALYSIS (thesis). James L. Setser (Kentucky. Univ., Lexington). 1963. Contract AT(40-1)-2670. 90p.

Chemical and radiometric procedures for the quantitative determination of zirconium and hafnium at the microgram and sub-microgram level by neutron activation analysis were developed. The radiochemical separations were carried out by the use of anion-exchange, solvent extraction, and gravimetric precipitations. Both zirconium and hafnium were determined by gamma counting. Experimental values for the cosmic abundances of zirconium and hafnium of 56 and 0.16 ($Si = 10^6$), respectively, were deduced from abundance data obtained from chondritic meteorites. Experimental determinations of the abundance of hafnium in achondrites, tektites, troilite, and deep-sea sediments are given. Data on the abundances of zirconium and hafnium in iron meteorites, troilite, and the standard rocks G-1

and W-1 are presented and compared with the previous determinations. Some geochemical properties of zirconium and hafnium were derived from the distribution of the elements in different meteoritic phases. (auth)

**31987** (AAEC/Trans-14) HELIUM RESEARCHES. VIII. A METHOD OF QUANTITATIVE MEASUREMENT OF SMALL AMOUNTS OF HELIUM. F. Paneth and Wm. D. Urray. Translated by D. Kairaitis (Australia Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales) from Z. Phys. Chem. (Leipzig). A152: 110(1931). 14p.

A method of gas measurement in the volume range $10^{-4}$ to $10^{-8}$ cc utilizing Töpler gas transport and Pirani-Stern hot-wire manometer principles is described. Sources of error are discussed, and methods of avoiding them are given. (auth)

**31988** (CEA-tr-A-1197) NOUVELLE MÉTHODE DE DÉTERMINATION DE LA CONCENTRATION DU THORIUM DANS UNE SUBSTANCE, BASÉE SUR L'EMPLOI DE PLAQUES A ÉMULSION NUCLÉAIRE. (New Method of Determination of Thorium Concentration in a Substance Based on the Use of Nuclear Emulsion Plates). J. Benisz, J. Koszelski, and J. Stoch. Translated into French from Mikrochim. Acta, 1: 59-64(1961). 10p.

A method for determining Th concentrations by the use of nuclear emulsion plates is described. The solution to be analyzed is introduced into the emulsion, and the number of stars having 2, 3, or 4 branches is measured. The Th content is determined with the aid of a diagram that indicates the number of stars per unit surface area as a function of concentration. The method permits the determination of Th down to a concentration of 10 ppb. (tr-auth)

**31989** DETERMINATION OF THE H–D ISOTOPE EFFECTS BY MEASUREMENT OF THE VANADIUM ELECTRODE POTENTIAL. V. Znamirovschi (Babes-Bolyai Univ., Cluj, Romania). Acad. Rep. Populare Romine, Studii Cercetari Fiz., 14: 233-7(1963). (In Rumanian)

The isotope effect of deuterium on the rest potential of the V powder electrode was shown experimentally. Regardless of the mechanism of this isotope effect, it can be used under certain conditions for the determination of deuterium concentrations in water as an analytical method. (tr-auth)

**31990** DETERMINATION OF MICRO AMOUNTS OF CALCIUM IN POTASSIUM CHLORIDE BY NEUTRON ACTIVATION ANALYSIS. F. W. E. Strelow and Heinrich Staerk (Technische Hochschule, Munich). Anal. Chem., 35: 1154-9(Aug. 1963).

A method for the determination of microgram amounts of Ca in alkali halides using neutron activation analysis was developed and applied to the determination of Ca in a number of samples of KCl. The determination was done by measuring the activity of the $Sc^{49}$, daughter of $Ca^{49}$. Radiochemically pure Sc was separated from large quantities of other radioisotopes by a procedure consisting of a hydroxide precipitation, a chromatographic ion exchange separation, a thenoyl trifluoroacetone complex extraction, and a final hydroxide precipitation. The separation procedure takes about 2 hr. About 0.5 $\mu$g of Ca or more can be determined with satisfactory accuracy. Ion exchange elution curves, decay curves for the separated $Sc^{49}$, and experimental data for the hydroxide precipitation and the liquid-liquid extraction steps are given. (auth)

**31991** DICESIUM PLUTONIUM HEXACHLORIDE, A PROPOSED PRIMARY STANDARD FOR PLUTONIUM. F. J. Miner, R. P. DeGrazio, and J. T. Byrne (Dow Chemical Co., Golden, Colo.). Anal. Chem., 35: 1218-23(Aug. 1963).

The salt, $Cs_2PuCl_6$, is suggested as a primary standard for Pu. It can be easily prepared in a pure state and with a constant composition. It is stable, has a high equivalent weight, and is readily soluble in dilute acids. (P.C.H.)

**31992** MICROACTIVATION ANALYSIS FOR OXYGEN IN THE ACTINIDE METALS. Andre C. Demildt (Univ. of California, Berkeley). Anal. Chem., 35: 1228-30(Aug. 1963). (UCRL-10324(Rev.))

$He^3$-activation analysis was found ideal for oxygen determination. By extrapolating from present data, it was estimated that O can be determined in as low a concentration as 0.001% in a few hundred micrograms of matrix material. Interference by activation of other elements can be partly restricted by control of the bombarding energy of the $He^3$ particles. This makes the method applicable to the analysis of fissionable actinides, since no nuclear reactions will occur between the target matrix and the bombarding particles if the kinetic energy is essentially lower than the coulomb barrier. (auth)

**31993** INDIRECT DETERMINATION OF THORIUM WITH (ETHYLENEDINITRILO) TETRAACETIC ACID. D. R. Rogers and W. B. Brown (Mound Lab., Miamisburg, Ohio). Anal. Chem., 35: 1261-3(Aug. 1963). (TID-18580)

An indirect (ethylenedinitrilo)tetraacetic acid (EDTA) titration procedure was developed for the determination of Th in the presence of impurities. A solution containing from 1 to 50 mg of Th is buffered at pH 3.0 ± 0.2 with sodium acetate and titrated at room temperature with EDTA to a xylenol orange end point. The sample is heated to boiling and a buffered fluoride solution is added that demasks the EDTA from the Th–EDTA complex. The free EDTA in the boiling solution is titrated with a standard Cu solution to a 1-(2-pyridylazo)-2-naphthol (PAN) end point. The procedure has a standard deviation within ± 0.18 and a mean error within ± 0.1 mg at the recommended concentration range. Twenty-seven cations were investigated as interferences; only Pu and Zr interfered. (auth)

**31994** ACTIVATION ANALYSIS FOR SODIUM IN THE SODIUM TUNGSTEN BRONZES. Robert J. Reuland and Adolf F. Voigt (Iowa State Univ., Ames). Anal. Chem., 35: 1263-7(Aug. 1963).

The neutron activation method was applied to the Na analysis of Na–W bronzes. The main obstacle was the large $W^{187}$ activity that was simultaneously produced with the $Na^{24}$ activity and that interfered with the counting of the latter. Destructive activation analyses were investigated in which the two activities were radiochemically separated in reactions of the bronzes with either nitrosyl chloride or bromine trifluoride. Several types of measurements by nondestructive testing were also tried, and one of these, in which the two $Na^{24}$ gamma rays were counted in coincidence in a well crystal, was found to have sufficient precision. The accuracy of the neutron activation method was established by analyzing cubic bronzes for which the Na concentrations were accurately known from x-ray analysis. (auth)

**31995** DETERMINATION OF SUBMICROGRAM QUANTITIES OF MANGANESE, SODIUM, AND COPPER IN NATURAL DIAMONDS BY NEUTRON ACTIVATION ANALYSIS. E. C. Lightowlers (London Univ.). Anal. Chem., 35: 1285-90(Aug. 1963).

The Mn content of 18 natural diamonds, and the Na and Cu content of 7 of the specimens, was measured quantitatively by neutron activation analysis. Gamma-scintillation

spectrometry was used to detect the 0.85-Mev gamma emission of $Mn^{54}$, the 1.37-Mev gamma emission of $Na^{24}$, and the annihilation radiation due to the positron emission of $Cu^{64}$. The specimens examined weighed between 5 and 100 mg, and the levels of impurity found were 0.002 to 0.09 ppm of Mn, 0.05 to 0.4 ppm of Na, and less than 0.0004 to 0.9 ppm of Cu. The precautions taken to avoid errors due to self-shielding and various forms of interference are discussed. (auth)

**31996** A FLUOROMETRIC PROCEDURE FOR THE DETERMINATION OF CEROUS ION. William A. Armstrong, Douglas W. Grant, and William G. Humphreys (Defence Research Chemistry Labs., Ottawa). Anal. Chem., 35: 1300-1(Aug. 1963).

A fluorometric technique for the determination of cerous ion is described. Regarding the application of the method to the analysis of Ce(III) in the presence of species other than Ce(IV), it is noted that any substance that absorbs near 250 or 350 mμ will reduce Ce(III) fluorescence. The effect of each substance present would have to be investigated before proceeding with the analysis. (P.C.H.)

**31997** DETERMINATION OF AMERICIUM-243 IN CURIUM-244. C. J. Banick, G. A. Carothers, and W. T. Donaldson (E. I. du Pont de Nemours and Co., Aiken, S. C.). Anal. Chem., 35: 1312-13(Aug. 1963). (TID-17393)

The technique of dilution mass spectrometry was applied successfully to the precise determination of $Am^{243}$ in the presence of an approximately equal quantity of $Cm^{244}$. Known mixtures of $Am^{241}$ and $Cm^{244}$ were analyzed by a mass spectrometer and it was found that the ionization efficiency of Am was about 50 times that of Cm. Curium-243, therefore, would not cause errors greater than 1% in the determination of Am-243 unless present in $Cm^{243}/Am^{243}$ ratio greater than 1 to 2. Thus the isotopic dilution technique was applied to a mixture of Cm and Am without chemical separation. (P.C.H.)

**31998** DIRECT DETERMINATION OF SOME ALKALI METAL IONS BY POTENTIOMETRIC TITRATION. G. A. Rechnitz, S. A. Katz, and S. B. Zamochnick (Univ. of Pennsylvania, Philadelphia). Anal. Chem., 35: 1322-3 (Aug. 1963).

The precipitation titration of alkali metal ions with tetraphenylborate was studied using the cationic sensitive glass electrode as the indicator electrode in the potentiometric measurements. As a result, a rapid direct method for the determination of the alkali metals was developed. The method has the advantage over existing techniques for the determination of alkali metal ions of requiring relatively little equipment and time, but it suffers from the disadvantage of being nonselective with respect to the individual ions in the group. For the determination of a given univalent cation in a mixture, some prior chemical separation is required. (P.C.H.)

**31999** QUANTITATIVE DETERMINATION OF TANTALUM AND NIOBIUM MINERALS AND OXIDES BY X-RAY FLUORESCENCE. Blanca G. de Wappner. Anales Asoc. Quim. Arg., 49: 285-92(Dec. 1961). (In Spanish)

The samples are melted with Na, $B_4O_7$ into a bead that corrects for matrix effects. The line intensity plot, as a function of concentration, is linear with 6% precision over the entire range from 0 to 100%. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32000** DETERMINATION OF URANIUM IN ORGANIC SOLVENTS. J. Petrement-Eguiluz and F. Palomares-Delgado. Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. B, 57: 745-50(1961).

A method for the determination of U in tributyl phosphate–kerosene extracts, which are formed during the extraction of U, is described. The U content of the organic solution is determined approximately by density measurement. A suitable amount of solution is then pipetted into a 50-ml separatory funnel and treated with a solution of 20% tributyl phosphate and 80% kerosene. For back extraction of the U, 20 ml 2N $H_2SO_4$ and 20 g granulated Cd are shaken 3 min and separated into two phases. The determination of U follows in the aqueous phase as $U(SO_4)_2$ or with $Na_2CO_3$-NaOH-$H_2O_2$. For very dilute solutions, a spectrophotometric determination of U directly in the organic tributyl phosphate–kerosene extraction solution with dibenzoylmethane is suggested. (Uranium Abstr. Vol. 2; No. 5, July 1963)

**32001** SPECTROPHOTOMETRIC DETERMINATION OF THE MICROAMOUNTS OF URANIUM PREVIOUSLY EXTRACTED WITH METHYL ISOBUTYL KETONE–TRIBUTYL PHOSPHATE. J. Vera Palomino, F. Palomares Delgado, J. Petrement, and R. Fernandez Cellini (Junta de Energia Nuclear, Madrid). Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. B, 59: 285-302(Apr. 1963). (In Spanish)

Selective extraction of uranium in nitric acid medium with a mixture of TBP–methylisobutylketone (1 : 10) was achieved. Aluminum nitrate was used as salting agent. Complexing agents were added in order to avoid extraction of impurities. Extraction conditions were studied so that extraction was almost practically complete in a single run. Uranium was determined by colorimetry based on the yellow color developed by the complex of uranium with dibenzoylmethane. The method was modified to be applicable to alcoholic medium extraction. The optical density was measured with a spectrophotometer at 410 mu. Statistical treatment of the results obtained with this method was compared with the results found with the NaOH–$H_2O_2$ method, in which uranium is first separated by ion exchange and the confidence bands for the calibration ion curves were determined. (auth)

**32002** SPECTROPHOTOMETRIC DETERMINATION OF THE RARE EARTH ELEMENTS. I. EXPERIMENTAL RESULTS. J. Vera Palomino, F. de la Cruz Castillo, and R. Fernandez Cellini (Junta de Energia Nuclear, Madrid). Anales Real Soc. Espan. Fis. Quim. (Madrid), Ser. B, 59: 303-14(Apr. 1963). (In Spanish)

The absorption spectra of aqueous solutions of the perchlorates of the rare earth metals were studied with the exception of three elements: lutetium, thulium, and promethium. The study included the determination of the molar extinction coefficients and concentration factors of the absorption peaks of analytical interest followed by a comparison of the collected results with other already available data. The correction factors to be introduced in each particular case to compensate for the interferential effects brought about by the simultaneous presence of different elements with the element to be determined were calculated as well as the probable error affecting the determination of the concentration factors calculated for the spectral maxima of greater significance for the elements belonging to the cerium group. (auth)

**32003** APPLICATION OF THE URANYL SALT METHOD TO THE DETERMINATION OF ARSENIC BY THE OXYGEN FLASK TECHNIQUE. A. D. Wilson and D. T. Lewis (Dept. of Scientific and Industrial Research, London). Analyst, 88: 510-15(July 1963).

A modified oxygen flask technique is described for determining As in organic compounds, the conventional Pt

supports being replaced by Al spirals or steel gauzes, which resist attack by As during the vigorous combustion. A favorable gravimetric factor is ensured by the quantitative precipitation of the As as ammonium uranyl arsenate and subsequent ignition, under controlled conditions, to the black triuranium octaoxide, $U_3O_8$. Phosphate and vanadate form similar insoluble ammonium uranyl salts, and the method is not directly applicable to organic compounds containing these elements without prior separation. (auth)

**32004** THE DETERMINATION OF SILICON, ZINC AND MAGNESIUM IN GALLIUM ARSENIDE BY NEUTRON-ACTIVATION ANALYSIS. D. E. Green, J. A. B. Heslop, and J. E. Whitley (AEI Research Lab., Aldermaston, Berks, Eng.). Analyst, 88: 522-8(July 1963).

The use of short-lived isotopes in the determination of trace amounts of impurities in Ga arsenide is described. Methods are presented for determining Si, Zn, and Mg. The effect of thermal neutron self-shielding in the determination of Si and Mg was investigated and is shown to be insignificant. (auth)

**32005** DETERMINATION OF ZIRCONIUM-95 AND NIOBIUM-95 IN SEAWEED AND SEA WATER. B. L. Hampson (Ministry of Agriculture, Fisheries Radiobiological Lab., Lowestoft, Suffolk, Eng.). Analyst, 88: 529-33(July 1963).

A method is described for determining $Zr^{95}$ and $Nb^{95}$ in seaweed and sea water. Oxalic acid in $HNO_3$ is used to complex both elements, and, after destruction of the oxalic acid with potassium chlorate, Zr is precipitated as Zr phosphate and Nb as niobic acid. After removal of rare earth activities, Zr is separated as Ba fluorozirconate, decontaminated from other active isotopes, and finally ignited to $ZrO_2$; the Nb fraction is similarly decontaminated, and finally ignited to $Nb_2O_5$. The oxides are then determined by gamma spectrometry. (auth)

**32006** NON-DISPERSIVE INFRA-RED ANALYSIS OF MIXTURES OF WATER AND HEAVY WATER. C. A. Bosselaar (Philips' Gloeilampenfabricken, Nijmegen, Netherlands). Appl. Sci. Res., Sect. B, 10: 137-56(1963).

For the determination of small quantities of heavy water in water and vice versa it is possible to make successful use of the infrared absorption spectrum of the sample to be examined. The aim in view is limited, the application of a nondispersive infrared analyzer is sometimes more advantageous than that of the more universally applicable spectral apparatus. For the above determination it was found that for samples in the vapor phase a nondispersive infrared gas analyzer could be used if it had first undergone various technical changes. The use of liquid samples, however, offered important advantages in comparison with that of gaseous ones, both on account of differences in the absorption spectra and because of easier handling in practice. In the end it was possible in samples with a natural deuterium content still to demonstrate concentration differences of 0.001% $D_2O$, while in samples of highly concentrated heavy water (about 99.8% $D_2O$) concentration differences of 0.001% $H_2O$ were still demonstrable. The minimum required quantity was 0.2 ml or, respectively, 0.3 ml. For a single determination a time of 12 minutes was needed in either case. (auth)

**32007** FLUORESCENCE SPECTROMETRIC DETERMINATION OF TANTALUM AND COLUMBIUM AND SOME COMPANION ELEMENTS IN TANTALUM AND COLUMBIUM-CONTAINING MATERIALS. W. Rothmann. Arch. Eisenhuttenw., 33: 17-22(1962).

Three new x-ray spectrometric procedures and solution techniques for the analysis of Ta- and Cb-bearing materials were investigated. The determination of Ta and Cb in ores, slags, and alloys after chemical separation is reported. (Rev. Metal Lit., 19: No. 11, Oct. 1962)

**32008** NEUTRON ACTIVATION ANALYSIS. Atomics, 16: No. 4, 15-19(July-Aug. 1963).

The neutron activation analysis technique is explained, and the separation of various beta and gamma emissions, the measurement of the decay constants of the isotopes, and the subsequent assignment of the individual radiations to particular nuclei are discussed. Various reactions such as (n,γ), (n,p), (n,2n), and (n,α) are considered. Factors that affect the sensitivity of the neutron activation technique are also discussed. (C.E.S.)

**32009** NEUTRON SOURCES FOR ACTIVATION ANALYSIS. Atomics, 16: No. 4, 20-5(July-Aug. 1963).

Several positive-ion accelerators that are used as neutron sources for activation analysis are described. These accelerators produce neutrons from (p,n) or (d,n) reactions. The Van de Graaff accelerator and two portable neutron generators are illustrated. A mobile reactor capable of intense neutron fluxes of short duration is also discussed. An automatic neutron activation analysis system designed for the determination of oxygen in materials is also considered. (C.E.S.)

**32010** DISPLAY AND INTERPRETATION OF GAMMA SPECTRA. Atomics, 16: No. 4, 25-9(July-Aug. 1963).

Radiation analysis systems for the display and interpretation of gamma spectra from neutron activation analysis are discussed. The scintillation counter in conjunction with a photomultiplier tube is used as the radiation detection system. A multichannel pulse-height analyzer and its associated readout and computer devices are used for interpretation of the spectra. For some analyses an oscilloscope display or typewriter readouts are shown to be satisfactory. Several examples of gamma spectra interpretation and display are illustrated. A complete, integrated system for neutron activation analysis is also illustrated. (C.E.S.)

**32011** APPLICATIONS OF NEUTRON ACTIVATION ANALYSIS. Atomics, 16: No. 4, 29-33(July-Aug. 1963).

Applications of neutron activation analysis in the fields of criminology, medical and biological research, nutrition, and industry are discussed. Potential uses for this technique are also considered. (C.E.S.)

**32012** GAMMA-RAY SPECTROSCOPY ON THE PRODUCTION LINE. Robert E. Lichty. Atomics, 16: No. 4, 34-6(July-Aug. 1963).

The use of gamma-ray spectroscopy to determine the uranium-235 content in reactor fuel elements is reported. The precision of this method compared to older methods of density determination and chemical analysis is discussed. The gamma-scanning technique is shown to be the most accurate and most convenient tool for establishing uranium-235 content. (C.E.S.)

**32013** RAPID DETERMINATION OF RADIATION BY SORBE-MULSION METHOD. B. Vlcek. Cesk. Hyg., No. 8, 475-81(1962).

Sorbemulsimetry is the term used for the original method of determining radioactive ions in solutions. The method is based on the selective adsorption of the radioactive ions on glass plates with a layer of hardened gelatine in which the adsorbent is dispersed. By shaking the plate with the solution, an almost ideal two-dimensional source of radiation is obtained, and radiation can be monitored by the usual counters. The preparation and use of adsorption plates with $BaSO_4$ are described. Radioactive isotopes can be adsorbed

with a selectivity corresponding to natural conditions from solutions buffered to pH 3 after the addition of complexon III and albumin. Differentiation of Ra isotopes is possible by changes in the alpha activity of the plate with time. The determination of Ra in water, urine, and other biological material is described. (Meditsinskiy Referativnyy Zhurnal, Razdel 7, No. 4, 1963)

**32014** STUDY OF THE POSSIBILITIES OF THE USE OF THE ABSORPTION OF BETA RADIATION FOR THE DETERMINATION OF URANIUM AND THORIUM IN WATER SOLUTIONS. J. Tolgyessy and P. Dillinger (Slovak Technical Univ., Bratislava). Chem. Zvesti, 17: 439-44(1963).

A method developed for the determination of Th and U is described. A calibrated curve is used, and the method is based on a definite geometric arrangement of the equipment used. Results of analyzing U and Th are given. The method is suitable for other metals having beta radiation. (TCO)

**32015** THE POSSIBLE SELECTIVE DETERMINATION OF CERTAIN LIGHT ELEMENTS ON THE BASIS OF THE YIELD OF THE $(\alpha,n\gamma)$ AND $(\alpha,p\gamma)$ NUCLEAR REACTIONS. I. N. Plaksin, M. A. Belyakov, and L. P. Starchik. Dokl. Akad. Nauk SSSR, 150: 1270-3(June 21, 1963). (In Russian)

Elements with low atomic numbers, such as Be, B, and Li, may be quantitatively determined on the basis of the secondary radiation of the $(\alpha,n\gamma)$ and $(\alpha,p\gamma)$ reactions of their nuclei. If several elements are present simultaneously in the sample, their concentrations may be selectively determined, even without using $\gamma$-spectrographic devices, by taking advantage of the dependence of the cross section of the nuclear reactions for $\alpha$ particles on the energy of the reaction. If the kinetic energy of the $\alpha$ particles is decreased, it becomes improbable that the nucleus of an element with a high Coulomb barrier, i.e., with high order number, can be penetrated. Thus, by reducing gradually the energy of the $\alpha$ particles, a point will be reached at which only light elements with a low energy threshold are selectively excited. The neutron yields of $(\alpha,n)$ reaction of Be and F using BeO and $CaF_2$ samples and a 1.5 mC $Po^{210}$ source were measured. Similar tests were carried out on the yield of the $\gamma$ radiation which accompanies the $Be(\alpha,n)C^{12}$ and the $F^{19}(\alpha,n\gamma)Ne^{22}$ reactions. The concentration of Be or B may be determined in the presence of other elements by placing a heavy-metal filter on the surface of the Po source, as the thresholds of the other elements are too high. If both B and Be are present in the sample, $\alpha$-activation analysis may be used for the selective determination. (TTT)

**32016** ANALYSIS OF IRON AND LIME IN DRILL CORE SAMPLES OF LORRAINE IRON ORES, USING X-RAY FLUORESCENCE EXCITED BY MEANS OF RADIOACTIVE SOURCE. G. Seibel and J. Y. Le Traon (Institut de Recherches de la Sidérurgie, Saint Germain en Laye, France). Intern. J. Appl. Radiation Isotopes, 14: 259-71 (July 1963). (In French)

The method used is based on nondispersive spectrometry of fluorescent x radiation excited in the specimens by the bremsstrahlung of a radioactive tritium source absorbed in titanium. The fluorescent x radiation is detected by a sealed proportional counter, which enables a spectrometry of this radiation to be carried out by pulse-height analysis. As the apparatus operates in air, only the characteristic radiation of iron and calcium can be detected. The pulse-height analyzer used includes two channels, allowing for simultaneous recording of the intensity of the iron and calcium radiations. The detector head is free to move along the length of the drill sample, thus allowing one to record the variations of the intensities of the iron and calcium radiations along the axis of the sample at a maximum speed of 3 m/hr. In addition, the measurement of the average intensity by impulse counting enables the concentrations of iron and calcium in a fragment of the sample to be evaluated, after calibration, with an absolute precision of about 3 per cent. (auth)

**32017** MOISTURE MEASUREMENTS BY MEANS OF NEUTRONS. H. Westmeyer (Forschungsinstitut Manfred von Ardenne, Dresden). Kernenergie, 6: 276-9(June 1963). (In German)

In connection with the problem of technical moisture measurements carried out with the help of neutrons, an investigation was made of whether a mathematical treatment of the elementary age-diffusion theory is able to furnish a basis for the outline of a measurement arrangement. A comparison of calculation and experiment showed, with sufficient exactness, that this is the case. (tr-auth)

**32018** MOLDING SAND MOISTURE MEASUREMENTS BY MEANS OF A $BF_3$ COUNTER PROBE. R. Schroller and H. Stiede (Forschungsinstitut Manfred von Ardenne, Dresden). Kernenergie, 6: 279-85(June 1963). (In German)

An investigation was made of $BF_3$ counters, especially with regard to obtaining a high constancy of experimental procedure, on the basis of which a probe for moisture measurements in loose materials could be constructed. With this probe, results were obtained from measurements on molding sand in a foundry. (tr-auth)

**32019** LARGE-AREA METHANE FLOW COUNTER FOR CONTAMINATION MEASUREMENT OF RADIOACTIVE WASTE WATERS. H. Schmidt (Institut für Angewandte Isotopenforschung der Institut für Medizin ind B Biologie der Deutschen Akademie der Wissenschaften, Berlin). Kernenergie, 6: 286-9(June 1963). (In German)

With limited expenditures a methane large-surface flow detector was constructed. The detector can be operated with any counting apparatus which supplies 3 kv and possesses an unpreregulated amplifier with a sensitivity of ≈500 mv. The effectiveness of the detector was determined for some nuclides by comparison with standardized-activity solutions whose activity depends on the salt concentration in waste water and on the maximum $\beta$ energy. For an effectiveness of 45% for average salt concentration, the activities were detectable with a certainty of $\approx 10^{-7}$ $\mu$C/ml. (tr-auth)

**32020** SELENIUM PURITY EXAMINATIONS BY ACTIVATION ANALYSIS. H. Koch and B. Koch (Institut für Angewandte Radioaktivität, Leipzig). Kerntechnik, 5: 248-51(June 1963). (In German)

The investigations were intended to determine the quantity of trace impurities of selenium used for the production of rectifiers. A combined process makes it possible with simple means to separate quickly chemically the elements to be detected. In this manner, it is possible to determine quantitatively the Cu, Br, As, Te, and Sb content of Swedish selenium. (auth)

**32021** THE PHOTOMETRIC DETERMINATION OF CERIUM BY ORTHO-DIANISIDIN IN HEAT RESISTANT ALLOYS. Hans-Joachim Thomann and Ursula Junghans. Neue Huette, 7: 421-4(July 1962). (In German)

The quantitative chemical analysis of 0.01 to 0.5% Ce in heat-resistant alloys including Ni- and Co-base alloys, by a photometric technique based on the formation of the Ce–o-Dianisidin complex is reported. (Rev. Metal. Lit., 19: No. 11, Nov. 1962)

**32022** DETERMINATION OF OXYGEN BY 14 MEV NEUTRON ACTIVATION ANALYSIS USING A NEW ANALYTICAL INSTRUMENT. Isao Fujii (Tokyo Shibaura Elec. Co.), Haruo Muto, Kazuyuki Ogawa, and Akira Tani. Nippon Genshiryoku Gakkaishi, 5: 455-61(June 1963). (In English)

A new analytical instrument using a 14-Mev neutron generator for industrial purposes is described. The instrument is made up of three parts: a 14-Mev neutron generator ($10^{10}$ n/sec), an automatic control system, and a system of measurement. The neutron generator is a Cockcroft-Walton type accelerator, and the automatic control system has a sample transfer system and a C-R neutron monitoring system which corrects automatically the influence of the fluctuation of neutron flux during the bombardment of samples. The accuracy of the measurement using this analytical instrument is within ±5% at an oxygen level of 10%. (auth)

**32023** ON THE DETERMINATION ISOTOPIC COMPOSITION AFTER EMISSION SPECTRA OF MOLECULES. A. G. Zhiglinskii and A. S. Kochemirovskii. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 47-54(1963). (In Russian)

Some reasons for deviation of intensity ratios of isotopic emission lines from the corresponding isotopic concentration ratios are discussed. Some possibilities of the precision and reproducibility increase of the determination of isotopic composition spectral analysis according to the emission spectra of diatomic molecules are illuminated. (auth)

**32024** AMPEROMETRIC TITRATION OF DIVALENT IRON IONS IN OXALATE BATH BY CERIUM(IV) SULFATE. V. I. Borovina, V. P. Novak, and V. F. Mal'tsev (Ukrainian Research Inst. of Tubing Engineering, USSR). Zavodsk. Lab., 29: 654-5(1963). (In Russian)

Amperometric determination of $Fe^{2+}$(0.10 to 4.00 g/e) in oxalate both by a $Ce(SO_4)$ 0.002N solution in presence of oxalic or sulfuric acid is described. The procedure takes about 7 min. (R.V.J.)

**32025** SCINTILLATION METHOD FOR SPECTRAL ANALYSIS OF TANTALUM AND NIOBIUM IN ORES. Ya. D. Raikhbaum, V. D. Malhkh, and M. A. Luzhnova (Irkutsk State Inst. of Rare Metals, USSR). Zavodsk. Lab., 29: 677-80(1963). (In Russian)

A spectral analysis was made of powdered substances by an arc flame. The pulses of evaporating are recorded by scintillation counter, and the concentration of the element in the mineral grain are estimated using the mineral formula and the number of grains. (R.V.J.)

**32026** EXTENSION OF NEUTRON ACTIVATION ANALYSIS TO $10^{-9}$ GRAM SAMPLES. Philip A. Benson and Chester E. Gleit (Tracerlab, Richmond, Calif.). 14p. (CONF-39-6)

From American Nuclear Society Annual Meeting, Salt Lake City, June 1963.

An experiment that was undertaken to develop suitable handling techniques and to determine the practical limits of size, accuracy, and reproducibility in performing neutron activation analyses to $10^{-9}$ is described. Stainless steel microspheres, with weights between $4.7 \times 10^{-9}$ and $3.9 \times 10^{-8}$ g, were isolated on methyl methacrylate films. After measuring particle diameters by optical microscopy, the specimens were encapsulated in Pb foil and irradiated with an intense flux of neutrons. Radiochemical procedures were used to isolate the $Mo^{99}$, $Cr^{51}$, $Fe^{55,59}$, and $Np^{239}$ fractions. The abundance of Mo, Cr, and Fe in the individual spheres was determined from the measured activities. In the case of Mo, the least abundant element, 1.94 + 0.25% Mo was found. This value, as well as the values for Cr and Fe, agreed with the concentrations found in larger specimens. The samples analyzed in the study are the smallest objects yet analyzed by neutron activation. (P.C.H.)

**32027** DETERMINATION OF CARBON IN URANIUM MATERIALS. B. Budĕšinský (Inst. of Nuclear Physics, Czechoslovak Academy of Sciences, Řež). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/64, 6p. (CONF-120-20). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Determination of the total content of C in U oxides and carbides was worked out. Samples were dissolved and oxidized in chromic and phosphoric acids. The $CO_2$ formed was determined colorimetrically through absorption in the alkaline alcohol–aqueous solution of salicyl yellow or phenolphthalein. If the content of C is higher (as in carbides), the $CO_2$ formed is absorbed in K methylate and determined through retitration with a standard solution of benzoic acid in dimethyl formamide, using azoviolet as indicator. The traces of rare earths in U were also determined. They were separated from U using column chromatography with Dowex 1 or 2 in HCl medium. Determination of the individual rare earths in the first fraction of the eluate was carried out through paper chromatography in the system ether–acetone–sulfocyanic acid. After detection with arsenazo III, the individual rare earths were determined also spectrophotometrically using arsenazo III. Conditions for the simultaneous determination of Th are also given. (P.C.H.)

**32028** THE DETERMINATION OF ALUMINUM BY ATOMIC ABSORPTION SPECTROPHOTOMETRY. David C. Manning, Sabina Sprague, and Walter Slavin (Perkin-Elmer Corp., Norwalk, Conn.). 18p. (CONF-48-2)

From Pittsburgh Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, Mar. 1963.

Aluminum can be determined by atomic absorption spectrophotometry using a fuel-rich oxyacetylene flame and chloride solutions of the samples. The instrumental parameters of the method were studied: fuel-to-oxygen ratio, distance above burner base, fuel and sample flows, etc. The method was successfully applied to the determination of aluminum in silica, cement, and steel. (D.L.C.)

**32029** DETERMINATION OF GAMMA ISOMER IN HEXACHLOROCYCLOHEXANE BY ISOTOPE DILUTION. Laura T. Atalla and Fausto W. Lima (Instituto de Energia Atomica, Sao Paulo, Brazil). 14p. (CONF-115-1; IEA-59)

From Pan-American Conference on Radiochemistry, Montevideo, Uruguay, July 1963.

The isotope dilution method, associated with chromatographic separation, was applied to analysis of the gamma isomer of hexachlorocyclohexane. The precision of the method is very good, giving a standard deviation of less than 0.1% for samples with about 10% of the gamma isomer. (auth)

## Inorganic and Physical Chemistry

*Refer also to abstracts 32587 and 32617.*

**32030** (AROD-006.9) DETERMINATION OF THE GEOMETRY OF LITHIUM OXIDE, $Li_2O(g)$, BY ELECTRIC DEFLECTION. Interim Technical Report No. 5, STUDY OF HIGH TEMPERATURE THERMODYNAMICS OF LIGHT

METAL COMPOUNDS. Alfred Buechler, James L. Stauffer (Little (Arthur D.) Inc., Cambridge, Mass.); William Klemperer, and Lennard Wharton (Harvard Univ., Cambridge, Mass.). June 1963. Contract DA-19-020-ORD-5584. 20p.

A conventional Ingram-type mass spectrometer was adapted to permit the study of the polarity of high-temperature species by electric deflection methods. The molecule $Li_2O$ was found to be nonpolar and therefore to have an equilibrium angle close to 180°, as shown by the absence of deflection of a molecular beam by an inhomogeneous electric field. The species LiO, which was found by Berkowitz, Chupka, Blue, and Margrave, was confirmed to form a small percentage of the vapor in equilibrium with solid $Li_2O$. (auth)

**32031** (BM-RI-6245) LOW-TEMPERATURE HEAT CAPACITIES AND ENTROPIES AT 298.15°K OF THE SESQUIOXIDES OF SCANDIUM AND CERIUM. W. W. Weller and E. G. King (Bureau of Mines. Berkeley Thermodynamics Lab., Berkeley, Calif.). Jan. 1963. 9p.

Low-temperature heat capacities of scandium sesquioxide ($Sc_2O_3$) and a mixture of cerium sesquioxide ($Ce_2O_3$) and cerium dioxide ($CeO_2$) were measured over the temperature range from 50 to 298°K. The entropy of scandium sesquioxide at 298.15°K was evaluated directly as $S^\circ_{298.15} = 18.4 \pm 0.1$ cal/deg mole. That of cerium sesquioxide was extracted by combining the heat-capacity data for the mixture with those for pure cerium dioxide; the result was $S^\circ_{298.15} = 36.0 \pm 1.0$ cal/deg mole. (auth)

**32032** (CNLM-5066) THE THERMAL DECOMPOSITION OF URANIUM NITRIDE. P. A. Vozzella, A. D. Miller and M. A. DeCrescente (Pratt and Whitney Aircraft Div., United Aircraft Corp. Connecticut Aircraft Nuclear Engine Lab., Middletown). [1962]. Contract [AT(11-1)-229]. 10p. (CONF-94-3)

From American Nuclear Society Meeting, Cincinnati, April 1963.

A study was made to provide a quantitative measure of the thermal stability of UN and to establish its thermodynamic properties. Preliminary Langmuir experiments indicated that UN decomposes to nitrogen and uranium, losing nitrogen at a much faster rate than uranium. The surface of a UN specimen was almost completely covered with uranium after being heated for 30 min at 3400°F in vacuum. Knudsen experiments were also carried out. It was estimated that the accommodation coefficient for $N_2$ over UN is approximately 0.01 to 0.04 in the temperature range 2900 to 3150°F. (M.C.G.)

**32033** (CONF-20-5) MASS SPECTROMETRIC STUDY OF THE VAPORIZATION OF PRASEODYMIUM–GROUP V COMPOUNDS. K. A. Gingerich (Pennsylvania State Univ., University Park); and J. Efimenko (National Bureau of Standards, Washington, D. C.). [nd]. Contract AT(30-1)-2541. 8p.

From Third Rare Earth Conference, Clearwater, Florida, Apr. 1963.

The vaporization of the praseodymium-group V compounds, PrP, PrAs, PrSb, and PrBi, was studied by the Knudsen effusion method in combination with a mass spectrometer. No vapor species containing both Pr metal and a group V element was observed. The vaporization occurred by decomposition into the respective group V element and a condensed Pr-rich phase. Heats of dissociation of 124, 114, and 98 kcal were obtained for the arsenide, antimonide, and bismuthide, respectively. The ion intensities were related to approximate vapor pressures. According to these the stability of the compounds decreased with increasing atomic number of the group V element. From the ion intensity variation with composition it was concluded that all compounds exhibit broad ranges of homogeneity that are possibly temperature dependent. (auth)

**32034** (CONF-20-22) ELECTROCHEMICAL CHARACTERISTICS OF THE RARE EARTH AND YTTRIUM METALS IN PHOSPHORIC ACID. Norbert T. Greene and Linda Lee (Rensselaer Polytechnic Inst., Troy, N. Y.). [1963]. Contract AT(30-1)-1995. 14p.

From 3rd Rare Earth Conference, Clearwater, Fla., April, 1963.

Anodic polarization and hydrogen overpotential characteristics of the rare earth metals were determined in $0.1\overline{N}$ phosphoric acid using potentiostatic and galvanostatic techniques. Yttrium, because of its similarity, was included for comparison. (auth)

**32035** (CONF-20-28) ON RARE EARTH BORATES OF COMPOSITION $3R_2O_3 \cdot B_2O_3$. S. F. Bartram (General Electric Co. Advanced Technology Services, Cincinnati). [1962]. Contract [AT(11-1)-171]. 22p. (TM-63-2-17)

From Rare Earth Conference, Clearwater, Fla., Apr. 1963.

In connection with previous studies on the $RBO_3$-type borates, compounds between the rare earth oxides and boric oxide were prepared at the composition $3R_2O_3 \cdot B_2O_3$. These compounds form three structural types which contain the same rare earth members as do the $RBO_3$ normal orthoborates. X-ray crystallographic data are given for the 3:1 borates of the rare earths, lanthanum, and yttrium. Although all of these compounds crystallize with monoclinic symmetry, the larger La, Pr, and Nd ions produce a structure completely different from the smaller rare earth ions. Another less radical structure change occurs between ytterbium and lutetium. The borate ion configuration in these structures is compared with that found in other complex borates. (auth)

**32036** (CONF-40-2) THE STABILITY OF MOLTEN URANIUM AND REFRACTORY CARBIDES IN HIGH VACUUM. S. G. Nelson, E. L. Foster, Jr. (Battelle Memorial Inst., Columbus, Ohio); and J. Alfred Berger (Pittsburgh. Univ.). [1962]. Contract W-7405-eng-92. 34p.

From Sixth Annual Conference on Vacuum Metallurgy, New York, New York, June 1963.

An electron beam technique is described for the study of the thermodynamic properties of materials at extremely high temperatures. This technique, a modification of the Langmuir method, was then used to measure the evaporation rates and vapor pressures of molten carbides of uranium, tungsten, niobium, zirconium, tantalum, vanadium, and titanium. The evaporating species from each of these carbides were identified by chemical analysis and by metallographic examination. (auth)

**32037** (CONF-50-14) DISLOCATION MOVEMENT IN SINTERING OF CALCIUM FLUORIDE. C. S. Yust and C. S. Morgan (Oak Ridge National Lab., Tenn.). [1961]. Contract W-7405-eng-26. 15p.

From American Ceramic Society Annual Meeting, Pittsburgh, Pa., April-May 1963.

The formation of weld necks between calcium fluoride crystals at elevated temperature was examined. An etchant selective in revealing dislocation intersections with crystal surfaces indicated massive concentrations of dislocations around the positions where $CaF_2$ particles sintered to the surface of larger $CaF_2$ crystals. The presence of the dislocations is thought to indicate that plastic flow con-

tributes to the formation of the weld neck. Changes in the microstructure around a small hole in a calcium fluoride powder compact during sintering suggest extensive plastic deformation in the area of the hole. (auth)

**32038** (CVNA-129) A DIGITAL COMPUTER PROGRAM FOR FINDING SOME THERMODYNAMIC PROPERTIES OF HEAVY WATER (DEUCO). William A. Webb and John D. Phillips (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). July 1963. For Carolina Virginia Nuclear Power Associates, Inc., Parr, S. C.). Contract [AT(30-1)-2289]. 35p.

The program DEUCO consists of four subroutines for finding thermodynamic properties of heavy water in the saturated and two-phase regions. One subroutine allows use of light water calling sequences. The program is described, and the program formulation and heavy water properties tabulation are included. (D.C.W.)

**32039** (LA-2900) DETONATION PROPERTIES OF CONDENSED EXPLOSIVES COMPUTED USING THE BECKER-KISTIAKOWSKY-WILSON EQUATION OF STATE. Charles L. Mader (Los Alamos Scientific Lab., N. Mex.). Feb. 19, 1963. Contract W-7405-eng-36. 324p.

The history and theoretical basis of the Becker-Kistiakowsky-Wilson (BKW) equation of state are reviewed, and the results of an extensive parameter study are described. The covolumes of water and carbon dioxide were changed to 250 and 600, respectively, to obtain better agreement with the experimental Hugoniots. Using these covolumes, a single set of BKW equation-of-state parameters could not be found that would reproduce the experimental detonation properties of TNT and RDX within experimental error. The BKW equation-of-state parameters that would reproduce the detonation velocity-density curve of RDX from 1.8 to 1.0 g/cc were found to result in a physically unrealistic behavior above 0.5 megabar. It was found that the BKW equation-of-state parameters $\alpha = 0.5$, $\beta = 0.16$, and $\kappa = 10.91$ were satisfactory for most explosive systems and that $\alpha = 0.5$, $\beta = 0.09585$, $\kappa = 12.685$ were satisfactory for high-density explosives whose detonation products contain large amounts of solid carbon. The computed detonation properties using these equation-of-state parameters and covolumes are presented for several explosives. (auth)

**32040** (NYO-10552) THE CRYSTAL AND MOLECULAR STRUCTURE OF BIS-(DIPIVALOYLMETHANIDO) ZINC(II). F. A. Cotton and J. S. Wood (Massachusetts Inst. of Tech., Cambridge. Dept. of Chemistry). Aug. 9, 1963. Contract AT(30-1)-1965. 24p.

A single crystal, three-dimensional x-ray study of bis-(dipivaloylmethanido)-zinc(II) was carried out. The results confirmed an earlier deduction from space group requirements that the metal atoms lie at positions of $\bar{4}$ symmetry and are thus in "tetrahedral" (strictly $D_{2d}$) complexes. The space group also requires that each chelate ring be precisely symmetrical. The important bond lengths and angles in the chelate rings (standard deviations in parentheses) are: Zn–O 1.962 (0.007); C–O, 1.274 (0.012); C–C, 1.405 (0.012); <OZnO, 94.7° (0.6); <OCC, 125.8° (1.1); <CCC, 127.0° (2.8). The remaining <OZnO's are 114.2° (0.6). These dimensions were compared with those in some other $\beta$-ketoenolate complexes. The considerable distortion of the immediate environment of the cobalt atom, in the isostructural cobalt(II) complex, from perfect tetrahedral symmetry can be considered as an important cause of the somewhat anomalous characteristics of the visible absorption spectrum of that compound. (auth)

**32041** (ORNL-3413) VIBRATIONAL SPECTRA OF MOLTEN SALTS. D. W. James (Oak Ridge National Lab., Tenn.). July 26, 1963. Contract W-7405-eng-26. 24p.

Vibrational spectra provide one of the most direct methods for the study of composition and structure of simple covalently bound species. In molten salts, where the presence of complex ionic species is debated, the application of the powerful techniques of infrared and Raman spectroscopy was hampered by severe experimental difficulty. The literature from 1925 to the present time is reviewed, and unusual aspects of experimental techniques as well as the results obtained are covered. The discussion is limited to ionic salts except where the spectra of molecular liquids make a direct contribution to the understanding of related ionic liquids. Literature references number 62. (auth)

**32042** (TID-19123) MAGNETIC RESONANCE STUDIES OF UNPAIRED ATOMS IN SOLID $D_2$. Mark Sharnoff and R. V. Pound (Harvard Univ., Cambridge. Lyman Lab. of Physics). [1962]. Contract AT(30-1)-2382. 76p.

The ground state spectroscopic parameters, line shapes and breadths, relaxation times, and saturation behavior of unpaired atoms produced in samples of solid $D_2$ containing up to 1 atomic % $T_2$ were studied. The apparatus and procedures are described, and the results and their interpretation are discussed. (D.C.W.)

**32043** (TID-19124) THE COLLOID ABSORPTION BAND IN CESIUM BROMIDE. Special Report. Richard E. Jensen (Arizona State Univ., Tempe). July 1963. Contract AT(11-1)-715. 9p.

An optical extinction band in colored CsBr at 1050 mμ is attributed to colloidal cesium precipitates. The peak wavelength may be closely predicted by assuming the extinction is due to plasma resonance of conduction electrons in the cesium particles. The band is relatively insensitive to temperature change. The band width decreases as the particle size increases. The shape of the extinction curve is distorted at low temperatures, indicating a distortion of the particle shape. The band resists bleaching. (auth)

**32044** (TID-19183) ADSORPTION OF CESIUM BY HYDROUS FERRIC OXIDE AND LIMONITE. Progress Report No. 2, October 1, 1958 to May 15, 1959. A. A. Armstrong, Jr. and B. L. Baker (South Carolina. Univ., Columbia). Contract AT(38-1)-147. 23p.

An investigation was made on the adsorption of cesium on hydrous ferric oxide and limonite. The study of the adsorption of cesium on hydrous ferric oxide covered a range of solution pH from 6.0 to 12.0 and a range of equilibrium cesium solution concentrations from $1.0 \times 10^{-5}$ to $1.0 \times 10^{-1}$ meq/ml. The study of the adsorption of cesium on limonite covered a range of solution pH from 7.0 to 12.0 and a range of equilibrium cesium solution concentrations from $1.0 \times 10^{-5}$ to $1.0 \times 10^{-2}$ meq/ml. Investigations were made on cesium solutions containing no NaCl and 1N NaCl. Cesium solution concentrations were determined by the radioactive tracer technique using $Cs^{137}$ tracer. From the experimental data, values of cesium equilibrium solution concentrations and solid phase concentrations were calculated. Isotherms (25°C) for the adsorption of cesium on hydrous ferric oxide and limonite were obtained by plotting the solid phase concentration versus the equilibrium solution concentration on log-log paper and drawing a smooth curve through the data points. The distribution coefficients for cesium between the solid and liquid phases were calculated from the isotherms. Then the distribution coefficients were plotted versus equilibrium solution concentrations. The distribution coefficient for the adsorption of cesium on hydrous ferric oxide

varied from 10.2 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times x^{-5}$ (meq/ml) to 11.9 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times 10^{-2}$ (meq/ml). The distribution coefficient for the adsorption of cesium on hydrous ferric oxide from a 1N NaCl solution varied from 5.60 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times 10^{-5}$ (meq/ml) to 6.10 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times 10^{-2}$ (meq/ml). The distribution coefficient for the adsorption of cesium by limonite varied from 56.0 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times 10^{-5}$ (meq/ml) to 2.10 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times 10^{-2}$ (meq/ml). The distribution coefficient for the adsorption of cesium by limonite from a 1N NaCl solution varied from 5.70 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times 10^{-5}$ (meq/ml) to 1.36 (meq/gm)/(meq/ml) at an equilibrium solution concentration of $1.0 \times 10^{-2}$ (meq/ml). The precision of the data is not sufficient to show a significant effect of pH on the adsorption of cesium although the data seem to indicate an effect. (auth)

**32045** (TID-19184) PART I: ADSORPTION OF CESIUM AND STRONTIUM. Progress Report No. 5, June 1, 1960 to September 1, 1960. T. H. Wilson and B. L. Baker (South Carolina. Univ., Columbia). Dec. 16, 1960. Contract AT(38-1)-147. 64p.

The adsorption of strontium and cesium by various silicates and hydrous $Al_2O_3$ was investigated using coprecipitation as the method. Adsorption of cesium by a previously precipitated adsorbent was determined in one series of tests. $Cs^{137}$ and $Sr^{89}$ were used as radioactive tracers to determine the amount of adsorption. Original cesium chloride solutions of $1.998 \times 10^{-2}$ to $1.998 \times 10^{-5}$ M and strontium chloride solutions of $0.999 \times 10^{-1}$ to $0.999 \times 10^{-5}$ M were used for this study. Range of pH values investigated varied from the pH at the complete precipitation of the adsorbent to pH 12. Strontium was adsorbed up to 99.8% by $Fe_2O_3 \cdot MgO \cdot 4SiO_2$ and up to 97% by $Al_2O_3 \cdot 3SiO_2$ and hydrous $Al_2O_3$ at high pH values, indicating that strontium was best adsorbed from the more basic solutions containing ferric compounds. Cesium was adsorbed up to 86% by $Fe_2O_3 \cdot Al_2O_3 \cdot MgO \cdot 7SiO_2$ and up to 78% by $Al_2O_3 \cdot 3SiO_2$. The presence of the aluminum ion was found advantageous for the adsorption of cesium by silicates even though hydrous $Al_2O_3$ alone adsorbed only 8% cesium. Coprecipitation was shown to have little advantage in the adsorption of cesium since 74% cesium was adsorbed by a previously precipitated quantity of $Fe_2O_3 \cdot Al_2O_3 \cdot MgO \cdot 7SiO_2$ while only 81% was adsorbed by the coprecipitation method using the same quantity of adsorbent and solution concentrations. Desorption of strontium on hydrous $Al_2O_3$ was almost complete by changing the pH of the solution from pH 10 to pH 5 while a similar pH change for cesium adsorbed on $Fe_2O_3 \cdot Al_2O_3 \cdot MgO \cdot 7SiO_2$ showed very little desorption. (auth)

**32046** (TID-19185) PART I: ADSORPTION OF CESIUM AND STRONTIUM BY FERRIC SILICATE. Progress Report No. 3, May 15, 1959 to December 31, 1959. T. H. Wilson and B. L. Baker (South Carolina. Univ., Columbia). May 26, 1960. Contract AT(38-1)-147. 43p.

The adsorption of cesium and strontium by ferric silicate was investigated using coprecipitation as the method. The ferric silicate was produced by complete precipitation of iron and silica from ferric chloride and sodium silicate solutions in the presence of cesium or strontium chloride. The ratio of $(SiO_2)/(Fe_2O_3)$ used was 3. The investigation covered a pH range from 6 to 12 and was adjusted by addition of 2.0N sodium hydroxide. The range of equilibrium solution concentrations for cesium varied from $1 \times 10^{-5}$ to $1 \times 10^{-1}$ meq/ml. The concentrations were determined using $Cs^{137}$ as a radioactive tracer. The range of equilibrium solution concentrations for strontium varied from $1 \times 10^{-5}$ to $1 \times 10^{-1}$ meq/ml for pH 6 and $1 \times 10^{-6}$ to $1 \times 10^{-1}$ meq/ml for pH 7 to 12. The concentrations were determined using $Sr^{89}$ as a radioactive tracer. Distribution coefficients between the solid and liquid phases were determined from the adsorption data. The coefficients for cesium were found to reach a maximum at pH 9, 10, and 11 and to decrease at pH 12 for each equilibrium solution concentration. The distribution coefficients for cesium varied from a low of 1.3 (meq/gm)/(meq/ml) at pH 6 and equilibrium solution concentration of $1 \times 10^{-1}$ meq/ml to a high of 100 (meq/gm)/(meq/ml) at pH 9, 10, and 11 equilibrium solution concentration of $1 \times 10^{-5}$ meq/ml. Distribution coefficients for strontium were found to reach a maximum at pH 11 and to decrease at pH 12 for each equilibrium solution concentration. The coefficients varied from a low of 9.2 (meq/gm)/(meq/ml) at pH 6 and equilibrium solution concentration of $1 \times 10^{-1}$ meq/ml to a high of 19800 (meq/gm)/(meq/ml) at pH 11 and equilibrium solution concentration of $1 \times 10^{-6}$ meq/ml. A study of desorption of strontium on ferric hydroxide indicated that the strontium could be desorbed from 99% adsorption to 3% adsorption by changing the pH from 10 to 5. Time studies on the adsorption of strontium by ferric hydroxide and ferric silicate indicated that time of contact had no effect on the adsorption. The solution was in equilibrium after 5 minutes contact which was the minimum time for mixing and sampling. (auth)

**32047** (TID-19198) AN INTERFEROMETRIC TECHNIQUE OF DENSITY MEASUREMENT APPLIED TO ALKALI METAL VAPORS ORIENTED BY OPTICAL PUMPING (thesis). Steven Michael Jarrett (Michigan. Univ., Ann Arbor). 1962. Contract [AT(11-1)-1112]. 124p.

The results of the application of an interferometric technique of density measurement to alkali metal vapors oriented by optical pumping are presented. Two experiments were performed. First, a study of the dependence of the signal strengths in the optical pumping of a Na vapor on the Na vapor density, spectral composition of the pumping light, and buffer gas pressure was made and compared with a calculation of these signals. In the second, a determination of the $Rb^{85}$–$Rb^{87}$ spin exchange cross section was accomplished utilizing the techniques developed in the first experiment. Previous spin exchange cross section measurements using optical pumping methods had very large uncertainties due to poor determinations of alkali metal vapor densities. A scanning Fabry-Perot interferometer was constructed to measure the densities in optical pumping cells. Spectral profiles of the light transmitted through the cell at room temperature and at temperatures at which optical pumping experiments were performed could be obtained by use of this instrument. These profiles were compared to yield the absorption coefficient as a function of frequency. A knowledge of the integrated absorption coefficient and the lifetime time of an alkali atom in the excited state allowed the density to be calculated. The error in this method was determined by the uncertainty in the lifetime, finite resolution effects, and errors in determining the integrated absorption from the spectroscopic data. The method was estimated to be reliable to about 11%. The results of the Na experiment are presented in the form of graphs of optical pumping signal strengths as a function of density for different spectral compositions of the pumping

light and buffer gas pressures. The graphs could be used to estimate vapor densities in other optical pumping experiments with an accuracy of about 50%. The results of the Rb experiment yielded a spin exchange cross section for $Rb^{85}-Rb^{87}$ collisions of $(1.70 \pm 0.21) \times 10^{-14}$ cm$^2$. This determination was more than an order of magnitude more accurate than previous cross section determinations using optical pumping primarily because of the improved density measurement. The work is in good agreement with the electron paramagnetic resonance experiments of Sands and Moos. (auth)

**32048** (TID-19213) $\nu_3$ AND $\nu_1$ BANDS OF THE $NT_3$ MOLECULE. Llewellyn H. Jones (Los Alamos Scientific Lab., N. Mex.); W. W. Brim, and K. Narahari Rao (Ohio State Univ., Columbus). [nd]. Contract AT(11-1)-882. 25p.

The $\nu_3$ band of the $NT_3$ molecule occurring at about 4.5$\mu$ was recorded with a high resolution spectrograph. The observed rotational structure was analyzed and the constants evaluated are $[B'_{(\nu_3)} - B''_{(\text{ground state})}] = -0.030_5$ cm$^{-1}$; $\nu_3 = 0.214$; $q = 0.007$ cm$^{-1}$; and $\nu_0 = 2184.76$ cm$^{-1}$. The $\nu_1$ band whose Q branch was located at 2014.1 cm$^{-1}$ was found to be much weaker than the $\nu_3$ band; these two bands are of comparable intensity in the $NH_3$ molecule. (auth)

**32049** (VDIT-77) STRUCTURE AND COMPOSITION OF URANATES AND RELATED URANIUM COMPOUNDS. A Literature Survey. Madeleine Seleborg (Aktiebolaget Atomenergi, Stockholm). June 1963. 75p.

One hundred and seventy-four abstracts concerning the crystal structure and chemical composition of uranates, uranium trioxide, and related uranium compounds were collected. The sources were Nuclear Science Abstracts and Chemical Abstracts from 1950 to March 1963. (M.C.G.)

**32050** (AEC-tr-5911) THE VAPOR PRESSURE OF CALCIUM AND STRONTIUM BELOW THE MELTING POINTS BY A TRACER TECHNIQUE. Yu. A. Priselkov and An. N. Nesmeyanov. Translated for Ames Lab., Ames, Iowa from Dokl. Akad. Nauk SSSR, 95: 1207-10(1954). 5p.

The vapor pressure of solid calcium was determined in the temperature interval from 475 to 670°C, and that of strontium from 400 to 600°C. The measurements were carried out by an effusion method combined with a tracer technique. The equipment used consisted of a unit for determining the vapor pressure, a vacuum unit, a high-frequency generator for induction heating, and units for controlling the temperature and measuring the vacuum. $Ca^{45}$ and $Sr^{90}$ were used as tracers. Values of vapor pressure for calcium ranged from $2.28 \times 10^{-4}$ to $5.76 \times 10^{-2}$ mm Hg std at 475 to 670°C, and those for strontium ranged from $1.42 \times 10^{-4}$ to $6.08 \times 10^{-2}$ at 400 to 600°C. (M.C.G.)

**32051** (AEC-tr-5920) FLUORIDES OF XENON AND RADON. A. B. Neiding. Translated by Lydia Venters (Argonne National Lab., Ill.) from Usp. Khim., 32: 501-7 (1963). 10p.

The preparation of fluorides of xenon and radon is reviewed. A comparison of the noble gases with halides from the viewpoint of their electronegativity is presented. (M.C.G.)

**32052** (AEC-tr-5938) DEPENDENCE OF THE GAS DIFFUSION COEFFICIENT ON THE MIXING RATIO. Anton Lonius. Translated by Lydia Venters (Argonne National Lab., Ill.) from Ann. Physik, 29: 664-78(1909). 14p.

Experiments are described that demonstrate a clear dependence of the diffusion coefficient on mixing ratio. Studies on $H_2-O_2$, $H_2-N_2$, $N_2-O_2$, $H_2-CO_2$, and He–Ar are summarized. The Stefan-Maxwell "diffusion constant" theory cannot be supported. Data indicated that the law of change cannot be formulated quantitatively, but qualitatively. (M.C.G.)

**32053** DIFFUSION IN ION EXCHANGE RESINS. Burton Hering and Harding Bliss (Yale Univ., New Haven). A.I.Ch.E. (Am. Inst. Chem. Engrs.) J., 9: 495-503(July 1963).

Observations on the rate of ion exchange in Dowex 50W resins are reported. Measurements were made under conditions where solid diffusion was the governing phenomenon for six pairs of ions, sodium–zinc, sodium–silver, silver-aluminum, zinc–copper, zinc–aluminum, and aluminum-cerium (trivalent). The effects of temperature and of resin cross-linkage were studied with the first system. Exchange in both directions was studied for each pair except the last. Interpretation with a Fick's law model was accomplished, and diffusion coefficients were obtained for each pair. Values were greatly dependent on the direction of the exchange as well as on the particular pair. Interpretation with a Nernst-Planck model was also accomplished and diffusivities for each ion were obtained. Values were greatly influenced by the nature of the second ion except in the case of sodium. The interpretation in this case required numerical solution of the flux equations. The solutions are presented for valence ratios of $\frac{1}{3}$ and $\frac{2}{3}$ with diffusivity ratios of 5, 10, and 20 and for valence ratios of 3 and $\frac{3}{2}$ with diffusivity ratios of $\frac{1}{5}$, $\frac{1}{10}$, and $\frac{1}{20}$. Activation energies were found to be 4 to 6 kcal/g mole for either model. Increasing the resin cross-linkage from 4 to 12% decreased the diffusion values by approximately 80%. The data were equally well represented with either model. In view of the simplicity of Fick's law, the use of this model is recommended for design purposes. (auth)

**32054** SEPARATION OF TITANIUM FROM RARE EARTHS, BERYLLIUM, NIOBIUM, IRON, ALUMINUM, THORIUM, MAGNESIUM, MANGANESE, AND OTHER ELEMENTS BY CATION EXCHANGE CHROMATOGRAPHY. F. W. E. Strelow (South African Council for Scientific and Industrial Research, Pretoria). Anal. Chem., 35: 1279-82(Aug. 1963).

A systematic study of the absorbabilities of cations with AG 50W-X8 resin in $H_2SO_4$ indicated that the difference in the equilibrium distribution coefficients of Ti(IV) and a considerable number of other ions is large enough for a good separation. This fact was applied to develop a cation exchange chromatographic procedure for the separation of Ti from Fe(III), Al(III), Be(II), Sc(III), Y(III), La(III), Th(IV), Mg(II), Mn(II), Co(II), Cu(II), Ni(II), Zn(II), and Cd(II). Titanium is eluted with 1N $H_2SO_4$ containing 1% of $H_2O_2$ as stabilizing agent to suppress hydrolysis, while the other ions stay on the column. Ions such as Ga(III), Fe(II), Hg(II), Hg(I), Tl(I), Ag(I), and Cs(I) remain on the column as well. Nb(V), V(V), Mo(VI), Ta(V), and W(VI) can be eluted from the column with 0.5N $H_2SO_4$ containing 1% $H_2O_2$ before the separation of Ti from the more strongly absorbed elements is started. Ta(V) and W(VI), however, tend to interfere by hydrolysis. Zr(IV) and U(VI) accompany Ti. The separations are satisfactory when up to 5 meq of Be or 10 meq of the other ions are present with Ti. (P.C.H.)

**32055** PURIFICATION OF PLUTONIUM SULFATE TETRAHYDRATE BY RECRYSTALLIZATION AND ION EXCHANGE. Albert W. Wenzel and Charles E. Pietri (New Brunswick Lab., N. J.). Anal. Chem., 35: 1324-5 (Aug. 1963).

A method is presented for the preparation of high-purity $Pu(SO_4)_2 \cdot 4H_2O$, even from grossly impure Pu waste solutions (>10% impurities) by successive recrystallization or by anion exchange purification. The highest purity obtained for the compound by consecutive recrystallization and by ion exchange purification was 99.98+ and 99.95%, respectively. Further purification of a high-purity tetrahydrate (99.98+%), by either an additional recrystallization or an ion exchange process, results in a material of greater than 99.995% purity. (P.C.H.)

**32056** SOME SIMPLE FEATURES OF THE MÖSSBAUER EFFECT. III. THE f-FACTOR FOR AN IMPURITY SOURCE IN A CRYSTAL. Harry J. Lipkin (Univ. of Washington, Seattle and Univ. of Illinois, Urbana). Ann. Phys. (N. Y.), 23: 28-37(July 1963).

For a crystal where the source is an impurity having a different mass but the same force constant as the host lattice atoms, the f-factor is shown to be nearly independent of the mass of the host lattice atoms. The f-factor is thus given to a good approximation by that calculated for a homogeneous crystal in which the masses of the host lattice atoms were all changed to be equal to that of the source atom. The result is obtained by deriving an expression for the change in f as the mass of the host lattice atoms is changed. This expression is an integral over the normal modes of the spectrum that is insensitive to the details of the spectrum and is always small. Similar results are obtained for the thermal shift in such a crystal. (auth)

**32057** STRUCTURE ANALYSIS FOR THE CARBIDES OF IRON, TUNGSTEN AND CHROMIUM USING THERMAL NEUTRONS. Dietrich Meinhardt and Otto Krisement. Arch. Eisenhuettenw., 33: 493-9(July 1962). (In German)

The lattice structure and atom arrangement of $Fe_3C$, WC, $Cr_3C_2$, and $Cr_{23}C_6$ were analyzed by thermal neutron diffraction using counter tube indication. (Rev. Metal Lit., 19, No. 12, Dec. 1962)

**32058** THE POLYMORPHISM OF A NUMBER OF RARE EARTH OXIDES AND THEIR INTERACTION WITH WATER. K. I. Portnoi, V. I. Fadeeva, and N. I. Timofeeva. At. Energ. (USSR), 14: 559-62(June 1963). (In Russian)

Pure $Sm_2O_3$ (99.83%), $Eu_2O_3$ (99.70%), and $Gd_2O_3$ (99.80%) were dissolved in dilute HCl, and precipitated with ammonia. The hydroxides were calcined at 700 to 750°C for 2 hours. X-ray analysis showed that these oxides consisted of a single phase with a body-centered, cubic lattice. The appearance of the stable, high-temperature, monoclinic modification was determined by calcining rare oxide pellets for 6 hours at a temperature of 800 to 1700°C in intervals of 100°C. X-ray analysis showed that the conversion of the cubic modification to the monoclinic form takes place at 900 to 1000°C for $Sm_2O_3$, at 900 to 1100°C for $Eu_2O_3$, and at 1000 to 1300°C for $Gd_2O_3$. The conversion is slow, but the rate increases with increasing temperature. The reverse transformation is so slow that none of the rare earth oxides showed an appreciable conversion of the monoclinic form into the cubic form. Rare earth oxide pellets were calcined for 6 hours at temperatures of 800, 1100, 1200, 1400, and 1650°C, and then, were tested for solubility in boiling water. After 10 to 20 hours boiling in water, the dissolution of rare earth oxide was 2 to 30% for a calcining temperature of 800 to 1100°C. Colloidal solutions were formed. The least solubility was observed at calcining temperatures of 1200 to 1650°C. All the pellets containing the high-temperature modifications of $Gd_2O_3$, $Eu_2O_3$, and $Sm_2O_3$ were unstable, and disintegrated completely after the first 10 hours of boiling in water. (TTT)

**32059** THE REDUCTION OF ZIRCONIUM DIOXIDE BY CALCIUM CARBIDE AND BY CALCIUM CYANAMIDE. G. A. Meerson, Yu. G. Olesov, and V. I. Pryalochnikov. At. Energ. (USSR), 14: 563-8(June 1963). (In Russian)

Thermodynamic calculations showed that it is possible to reduce $ZrO_2$ with calcium carbide or calcium cyanamide within a temperature range of 900 to 1200°C by the following reactions: $ZrO_2 + 2CaC_2 + 0.5N_2 = Zr(C,N) + 2CaO + 3C$ and $ZrO_2 + 2CaCN_2 = Zr(C,N) + 2CaO + C + 0.5N_2$. A pellet of $ZrO_2$ and the reducing agent ($CaC_2$ or $CaCN_2$) were heated in a nickel boat in an electric, stainless steel tube furnace. A saturated zirconium carbo-nitride (N + C (bound) = 50 at. %) was obtained with a 4 hour calcination at 1100°C in a stationary atmosphere of nitrogen. The ratio of nitrogen to bound carbon in the final product increased with increasing temperature, especially when calcium cyanamide was used as the reducing agent. Experiments on substituting an argon atmosphere for a nitrogen atmosphere showed that the nitrogen in calcium cyanamide ($CaCN_2$) actively reacts with $ZrO_2$ to form a saturated Zr(C,N) solid. If CO was removed from the reaction sphere by passing in a current of nitrogen, a saturated Zr(C,N) solution was obtained with only 80% of the theoretical amount of $CaCN_2$ that is required. $CaC_2$ reacted more readily with traces of water vapor and carbon monoxide than did $CaCN_2$. (TTT)

**32060** THE EXPERIMENTAL DETERMINATION OF THE SPECIFIC VOLUME OF HEAVY WATER AT HIGH TEMPERATURES AND PRESSURES. S. L. Rivkin and T. S. Akhundov. At. Energ. (USSR), 14: 581-2(June 1963). (In Russian)

The maximum error in measuring the specific volume of heavy water (99.87% $D_2O$) was within the limits of 0.02 to 0.10% because of the high accuracy of thermostating the piezometer containing the liquid (±0.005°C), the accuracy in measuring the temperature (±0.01 to 0.02°C) and pressure (±0.01%), and experimental corrections for the inert volume. The small spread in the experimental values (<0.02%), and the good agreement between independent measurements indicated that the chance error is small, and that the results are readily reproducible. The specific volume of $D_2O$ ($cm^3/g$) is given at temperatures of 275, 300, 325, 340, 350, 360, 365, 370, 375, 380, 390, 400, 410, 420, and 425°C over a pressure range of 50 to 340 $kg/cm^2$ in increments of 10 $kg/cm^2$. (TTT)

**32061** THE DEPOSITION OF CESIUM AND RUBIDIUM FROM $CO_2$ GAS ONTO VARIOUS MATERIALS. N. V. Brevnova, L. I. Vartanova, V. I. Polikarpov, and N. N. Yuzvuk. At. Energ. (USSR), 14: 585-6(June 1963). (In Russian)

If an exponential fall in concentration n of a long-lived activity from a gas along the length of a tube is given by the equation $n = n_0 e^{-k_0 x}$, a low coefficient of deposition $k_0 = 2.3 \times 10^{-3}$ $cm^{-1}$ is obtained. In order to take into account the formation of rubidium and cesium activities from krypton and xenon, the following differential equation must be solved: $dn = -k_0 n\, dx + \lambda_m n_m dt$, where $\lambda_m$ and $n_m$ are the decay constant and concentration of the parent activity. The ratio R of the number of atoms leaving the tube to the number of atoms formed in a tube of length l at $n_0 = 0$ is $R = (1/k_0 l)(1 - l^{-k_0 l})$. Carbon dioxide gas was passed through the active zone of a reactor, and was purified from iodine and bromine by passing through a silica gel column impregnated with silver nitrate. The $CO_2$ gas containing krypton and xenon activities was then put through a tube 0.1 cm in diameter and 100 cm long. The ratio of activities in the tube and on the filter at the end of the tube was de-

termined radiochemically. It was found that the coefficient of deposition $k_0$ was equal to $1.6 \times 10^{-2}$ cm$^{-1}$ for $Cs^{139}$, and $2.2 \times 10^{-2}$ cm$^{-1}$ for $Rb^{91}$. The accuracy of determining $k_0$ is about 20%. No change in the deposition coefficient could be detected on varying the gas velocity from 3 to 10 liters/min, or on varying the tube material (polyethylene, stainless steel, and duraluminum). (TTT)

**32062** THERMAL DECOMPOSITION OF THE LANTHANUM SULFATE HYDRATE $La_2(SO_4)_3 \cdot 9H_2O$. I. THE DIFFERENT HYDRATES—RADIOCRYSTALLOGRAPHIC STUDY OF THE ENNEAHYDRATE. Guy Pannetier and André Dereigne (Faculté des Sciences, Paris). Bull. Soc. Chim. France, No. 5, 1059-62(May 1963). (In French)

Thermogravimetric studies and differential thermal analysis made on the enneahydrate of lanthanum sulfate show the following intermediary phases: the hexahydrate $La_2(SO_4)_3 \cdot 6H_2O$, the tetrahydrate $La_2(SO_4)_3 \cdot 4H_2O$, and the anhydride $La_2(SO_4)_3$. Powder x-ray diffraction was the basis of the determination of the structure of the enneahydrate as a hexagonal cell (a = 10.98 and c = 8.11 Å) containing two molecules and belonging to the symmetry group $C_{6h}^2 = P_{3/m}^6$. (tr-auth)

**32063** SOLVOLYSIS IN LIGHT AND HEAVY WATER. V. EFFECT OF DIOXANE ON THE SOLVENT ISOTOPE EFFECT WITH t-BUTYL CHLORIDE. Wm. G. Craig, Leo Hakka, P. M. Laughton, and R. E. Robertson (National Research Council, Ottawa and Carleton Univ., Ottawa). Can. J. Chem., 41: 2118-20(Aug. 1963). (NRC-7456)

The rates of hydrolysis of t-butyl chloride in 60 vol % dioxane in light water at 20.099°C were $4.64 \times 10^{-4}$ and $4.62 \times 10^{-4}$ sec$^{-1}$, and at 20.106°C, $4.66 \times 10^{-4}$ sec$^{-1}$. Corresponding values at 20.106°C when $D_2O$ replaced $H_2O$ were $4.53 \times 10^{-4}$ and $4.36 \times 10^{-4}$ sec$^{-1}$ with slight scatter. The results indicate a ratio $k_{D_2O}/k_{H_2O}$ of 0.94 to 0.97. (P.C.H.)

**32064** REACTIONS OF URANIUM TETRACHLORIDE WITH TERTIARY PHOSPHINES. P. Gans and B. C. Smith (Univ. of London). Chem. Ind. (London), No. 22, (June 1, 1963).

Uranium tetrachloride forms solid addition compounds with the lower alcohols, but addition of a base to alcoholic solutions of $UCl_4$ promotes solvolysis by the removal of HCl. Addition of triphenylphosphine to a solution of $UCl_4$ in ethanol gives a precipitate of bis(triphenylphosphonium) hexachlorouranate (IV) (I), and quantitative yields are obtained on addition of concentrated HCl. Bis(triphenylphosphonium) hexachlorouranate(IV) is a green crystalline paramagnetic solid. Decomposition occurs above 180° and 2 equivalents of HCl are evolved consecutively with increasing temperature. Oxidation by air in boiling ethanol gives yellow crystalline bis(triphenylphosphonium) tetrachlorodioxouranate(VI) (II). Oxidation of an ethanol solution of $UCl_4$ and triphenylphosphine by chlorine gives green crystalline paramagnetic uranium tetrachloride-bis(triphenylphosphine oxide)(III). Further oxidation of the compounds (II) and (III) gives yellow crystalline uranyl chloride-bis(triphenylphosphine oxide). Ethyldiphenylphosphine, diethylphenylphosphine, triethylphosphine, and tri-n-propylphosphine behave similarly. The phosphonium compounds show a P-H stretching band in the infrared region near 2420 cm$^{-1}$, the uranyl compounds show a U = 0 stretching band at 920 cm$^{-1}$, and the phosphine complexes show a P = 0 stretching band in the region 1050-1080 cm$^{-1}$. (Uranium Abstr., Vol. 2; No. 5, July 1963)

**32065** THE POSSIBILITY OF EXTRACTION OF LESS-COMMON ELEMENTS FROM BAUXITES DURING ALUMINA PRODUCTION BY THE BAYER PROCESS. Elemer Papp. Freiberger Forschungsh., 69B: 117-30(1962). (In German)

The extraction of Ga, Zr, Be, Mo, $ThO_2$, and alkaline earth metal oxides from bauxite by direct electrolysis and by precipitation from acid solution is described. The feasibility and economic aspects of the various processes are compared. (TCO)

**32066** VISCOSITY OF HYDROGEN IN THE GASEOUS AND LIQUID STATES FOR TEMPERATURES UP TO 5000°K. Leonard I. Stiel and George Thodos (Northwestern Univ., Evanston, Ill.). Ind. Eng. Chem., Fundamentals, 2: 233-7(Aug. 1963).

A viscosity correlation for hydrogen was developed for reduced temperatures up to $T_R = 75$ and reduced pressures up to $P_R = 100$. Experimental viscosities available in the literature for hydrogen at moderate pressures were utilized to establish the atmospheric viscosity behavior of this substance. For each experimental high density value, the residual viscosity, $\mu - \mu^*$, was determined from the atmospheric pressure relationship and plotted against reduced density to produce a continuous curve for both the gaseous and liquid regions. This information enabled a plot of viscosity against reduced temperature and reduced pressure to be developed for this substance. Viscosity values of dissociating hydrogen for temperatures up to 5000°K were obtained from reported theoretical calculations and were plotted against temperature for constant pressures. (auth)

**32067** MULTIDENTATE LIGAND KINETICS. III. THE FORMATION AND DISSOCIATION OF TRIETHYLENETETRAMINENICKEL(II) AND TETRAETHYLENEPENTAMINENICKEL(II) AND THEIR EXCHANGE WITH RADIONICKEL ION. D. W. Margerum, D. B. Rorabacher, and J. F. G. Clarke, Jr. (Purdue Univ., Lafayette, Ind.). Inorg. Chem., 2: 667-77(Aug. 1963).

The kinetics of the formation and dissociation reactions of triethylenetetraminenickel(II) and of tetraethylenepentaminenickel(II) as well as their exchange reactions with radionickel ion were studied at 25°, $\mu = 0.1$, pH 4.5 to 7.5, using spectrophotometric, titrigraphic, and radiochemical methods. It is proposed that the 4- and 5-dentate ligands react with Ni by the stepwise formation of coördinate bonds, where the rate-determining step is the formation of the first Ni–N bond and the subsequent bonding is rapid. Similarly, the dissociation mechanism proposed involves the pre-equilibration of intermediately bonded species leading to the rate step of breaking the last Ni–N bond. On this basis it is possible to estimate the equilibrium constants for each of the reaction intermediates. The differences in the reaction-rate constants of the straight-chain polyamines (having from 2 to 6 nitrogens), as well as their protonated species, can be attributed entirely to statistical and electrostatic effects. The model should also be applicable to complexes containing other metal ions and other unbranched multidentate ligands. (auth)

**32068** GAS PHASE CHROMATOGRAPHY OF METAL CHELATES OF ACETYLACETONE, TRIFLUOROACETYLACETONE, AND HEXAFLUOROACETYLACETONE. Robert E. Sievers, B. W. Ponder, Melvin L. Morris, and Ross W. Moshier (Aerospace Research Labs., Wright-Patterson AFB, Ohio). Inorg. Chem., 2: 693-8(Aug. 1963).

The gas phase chromatography of metal chelates of acetylacetone, trifluoroacetylacetone, and hexafluoroacetylacetone was investigated. Chelates of the fluorine-containing $\beta$-diketones are more volatile and can be eluted at much lower column temperatures than corresponding

complexes of acetylacetone. Trifluoroacetylacetonato complexes of Be(II), Al(III), In(III), Cr(III), Fe(III), Cu(II), Rh(III), Zr(IV), and Hf(IV) were successfully eluted in the gas phase. Separations of multi-component mixtures of chelates were rapid and efficient. Geometrical isomers of Cr(III) trifluoroacetylacetonate were separated by gas–liquid chromatography. The separation of optical isomers by gas–liquid and gas–solid chromatography is discussed. (auth)

**32069** TRICHLOROACETATES OF LANTHANUM, NEODYMIUM, AND DYSPROSIUM. George P. Tilley and John E. Roberts (Univ. of Massachusetts, Amherst). Inorg. Chem., 2: 745-6(Aug. 1963).

Lanthanum, Nd, and Dy trichloroacetates were prepared and characterized. Vacuum pyrolysis of the anhydrous salts yields anhydrous metal chlorides. (auth)

**32070** IDENTIFICATION OF COMPLEX IONS OF NIOBIUM(V) IN HYDROFLUORIC ACID SOLUTIONS BY RAMAN AND INFRARED SPECTROSCOPY. O. L. Keller, Jr. (Oak Ridge National Lab., Tenn.). Inorg. Chem., 2: 783-7(Aug. 1963).

The Raman spectra of $K_2NbOF_5 \cdot H_2O$ dissolved in water and $K_2NbF_7$ dissolved in 1 to 50% HF were compared with the Raman spectra of crystalline $K_2NbOF_5 \cdot H_2O$ (which also can be considered as $K_2Nb(OH)_2F_5$), $CsNbF_6$, and $K_2NbF_7$ to show that the $NbOF_5^{2-}$ (or $Nb(OH)_2F_5^{2-}$) and $NbF_6^-$ ions are present in the solutions. The Raman lines characteristic of the $NbF_7^{2-}$ ion were not seen in any of the solutions. The infrared spectrum of $K_2NbOF_5 \cdot H_2O$ was recorded from 650 to 4000 $cm^{-1}$ to gain information on whether the $NbOF_5^{2-}$ or $Nb(OH)_2F_5^{2-}$ ion is present in the crystals and the solutions. The infrared and Raman spectra were found to be consistent with the presence of $NbOF_5^{2-}$ ions in the crystals, but they were not found to be consistent with the presence of $Nb(OH)_2F_5^{2-}$ ions. (auth)

**32071** THE STOICHIOMETRY OF PRASEODYMIUM OXIDE. J. M. Honig, A. F. Clifford, and P. A. Faeth (Purdue Univ., Lafayette, Ind.). Inorg. Chem., 2: 791-6 (Aug. 1963).

The variation in composition of Pr oxide was studied in the range 0.001 to 150 mm and at temperatures between 400 and 1000°C, using a vacuum microbalance. A set of stable compositions, which may be represented by the homologous series $\underline{m}PrO_2 \cdot 2Pr_2O_3$ ($0 \leq \underline{m} \leq 8$) or $Pr_nO_{2n-2}$ ($4 \leq \underline{n} \leq 12$), was encountered. Between 700 and 1000°C, it is necessary to exceed a critical pressure that increases from 0.1 to 15 mm to effect a change from hexagonal $Pr_2O_3$ to rhombohedral $PrO_{1.714}$. Enthalpy and entropy changes were calculated for the transition. The experimental results are interpreted in terms of electronic defects that accompany stoichiometry changes. It is pointed out that non-stoichiometric compounds should in general be associated with low entropies of formation. (auth)

**32072** PREPARATION AND PROPERTIES OF SEVERAL AMMONIUM URANIUM(IV) AND AMMONIUM PLUTONIUM(IV) FLUORIDES. R. Benz, R. M. Douglass, F. H. Kruse, and R. A. Penneman (Los Alamos Scientific Lab., N. Mex.). Inorg. Chem., 2: 799-803(Aug. 1963). (LADC-5567)

A series of anhydrous fluoride complexes was formed between $NH_4F$ and actinide tetrafluorides. Compounds with $NH_4F:MF_4$ (M = U or Pu) mole ratios of 4:1, 2:1, 7:6, 1:1, and 1:3 were prepared by reaction of stoichiometric quantities in sealed tubes or by gravimetric arrests during $NH_4F$ distillation. X-ray powder diffraction data are presented. Corresponding U(IV) and Pu(IV) compounds are isostructural. The $7NH_4F \cdot 6MF_4$ compounds are rhombohedral, $a_0$ = 9.55 and 9.42 Å, $\alpha$ = 107.4° for U and Pu. A method of chemical analysis for $NH_4$, U, and F on a single sample was developed using pyrohydrolysis, ion exchange, and volumetric techniques. (auth)

**32073** OXIDES OF NEPTUNIUM(V) AND NEPTUNIUM(VI) FROM MOLTEN SALTS. Donald Cohen (Argonne National Lab., Ill.). Inorg. Chem., 2: 866-7(Aug. 1963).

Evidence is presented to show the existence of $NpO_3 \cdot 2H_2O$. A brown precipitate formed when bubbling ozone through a solution of Np(V) in a $LiNO_3–KNO_3$ eutectic at 150°C was separated from the salt by washing the salt mixture with water and then dried. The product was identified as $NpO_3 \cdot 2H_2O$. The x-ray powder pattern of the compound is similar to that of $UO_3 \cdot 2H_2O$. Specific activity measurements show the compound to contain 72 ± 2% Np; $NpO_3 \cdot 2H_2O$ contains 73.8% Np. Thus, it was concluded that $NpO_3 \cdot 2H_2O$ was made. (P.C.H.)

**32074** RARE EARTH METAL-METAL HALIDE SYSTEMS. VI. PRASEODYMIUM CHLORIDE. Leonard F. Druding, John D. Corbett, and Bob N. Ramsey (Ames Lab., Ames, Iowa). Inorg. Chem., 2: 869-71(Aug. 1963). (IS-603)

Phase studies were made on the Pr–$PrCl_3$ system. The Pr–$PrCl_3$ system exhibits the formation of the slightly stable intermediate compound $PrCl_{2.3}$, as characterized by the equilibrium phase diagram. The compound melts peritectically at 659°C to Pr(s) and the solution of 18.3% Pr in $PrCl_3$, only slightly different from the eutectic at 645°C and 15.7% Pr. The $PrCl_{2.3}$ compound disproportionates into $PrCl_3$ and Pr about 65°C below its melting point. A significant solubility of salt in the solid metal was also noted according to the phase results. The bcc → hexagonal transition found at 798°C on cooling the pure metal occurs at 769°C in the presence of $PrCl_3$. (P.C.H.)

**32075** PREPARATION OF COLLOIDAL CHROMIC PHOSPHATE ($P^{32}$) FOR MEDICAL USE. A. M. Del Turco and R. Pietra (Laboratorio di Chimica Nucleare, Ispra, Italy). Intern. J. Appl. Radiation Isotopes, 14: 279-83 (July 1963). (In English)

A method for preparation of radioactive colloidal chromic phosphate (1 mC $P^{32}$/mg $CrP^{32}O_4$) for medical use was studied. The radioactive colloidal chromic phosphate does not hydrolyze and sediment. The particle size of 50 per cent of colloid is about 200 Å, and the other particles are condensed into aggregates. (auth)

**32076** HEAT CONDUCTIVITY OF $D_2O$ IN THE GAS PHASE. N. B. Vargaftik and L. S. Zaitseva (Ordzhonikidze Aviation Inst., Moscow). Inzh. Fiz. Zh., Akad. Nauk Belorussk. SSR, 6: No. 5, 3-6(May 1963). (In Russian)

The results are given of measuring heat conductivity of vapors of $D_2O$ and $H_2O$ at $p = 9.8 \times 10^4$ neutrons/$m^2$ in the temperature range from 100 to 500°C. The experiments proved the ratio $\lambda_{D_2O}/\lambda_{H_2O}$ to be a function of temperature. The results for the ratios of heat conductivities of the isotopes may be explained from the point of view of statistical physics. (auth)

**32077** HYDROLYTIC PRECIPITATION OF BASIC ZIRCONIUM SULFATE FROM SULFURIC ACID SOLUTIONS. M. A. Kolenkova and A. I. Lainer. Izv. Vysshikh Uchebn. Zavedenii, Tsvetn. Met., 5: No. 2, 112-17 (1962).

The precipitation of $ZrO_2$ from solutions of $ZrO_2$, $SiO_2$, $Al_2O_3$, $Fe_2O_3$, Mg, CaO, and $TiO_2$ was studied as a function of the $SO_3–ZrO_2$ ratio and of the solution acidity during lixiviation by $H_2SO_4$ at 85 to 95°C. (Rev. Metal Lit., 19: No. 11, Nov. 1962)

**32078** KINETICS OF ISOTOPE EXCHANGE BETWEEN HYDROGEN AND LIQUID AMMONIA ON HETEROGENEOUS CATALYSTS. R. Haul and D. Blennemann (Universität, Bonn). J. Catalysis, 1: 432-42(Oct. 1962). (Jul-106-PC)

The isotope exchange between H and liquid $NH_3$ was studied in the temperature range between −60 and 25°C at pressures up to 150 atm in the presence of various catalysts, in particular supported Pt catalysts. Comparative exchange experiments were carried out with gaseous $NH_3$ at pressures from 25 torr up to the saturation pressure (8.7 atm at 20°C). Group VIII metals catalyze the H/D exchange with liquid $NH_3$ even at temperatures below −60°C. The activity decreases in the order: Pt, Pd, Ni, and Fe. For a Pt−C catalyst suspended in liquid $NH_3$ the rate of exchange increases proportionally to the amount of catalyst in the range from 10 to 100 g/l. Platinum catalysts supported on C and on silica gave the same exchange constants per unit weight and resulted in the same activation energy irrespective of the widely different surface areas. The following apparent activation energies were obtained: Pt/C, 10.0 ± 0.5; Pt/$SiO_2$, 9.6 ± 0.6; Pd/C, 11.3 ± 0.7; Raney-Ni, 11.5 ± 0.8 kcal/mole. Comparative measurements with K amide indicated that this homogeneous catalyst has a considerably higher activity and a lower activation energy (5.4 ± 0.6 kcal/mole) than the heterogeneous catalysts. Contrary to exchange on the catalysts, transport processes are rate determining in the K amide system under the conditions investigated. While the rate of exchange in liquid $NH_3$ increases proportionally to the H pressure in the case of K amide a dependence on the square root of the hydrogen pressure was found for the platinum/carbon catalyst. The experimental results support the mechanism that: Isotope exchange occurs between chemisorbed H atoms and a chemisorbed $NH_3$ molecule. (P.C.H.)

**32079** THE INFRARED SPECTRA OF SOME $B^{11}$ LABELED DIBORANES. Joyce J. Kaufman (RIAS, Baltimore), W. S. Koski, and R. Anacreon. J. Mol. Spectry., 11: 1-10(July 1963).

The spectra of $B_2^{11}D_6$ and $B_2^{11}D_6$ are similar to those of normal diborane; however, there are pronounced differences in band structure, in shape of rotational envelopes, and positions of maxima of bands. With NaCl prism resolution, peaks that should show three separate bands, $B_2^{11}H_6$, $B^{11}B^{10}H_6$, and $B_2^{10}H_6$, show only one with slight shifts in positions of maxima. These differences are directly related to percent $B^{10}$ content. By calibrating an instrument with samples of diborane of known $B^{10}$ content, it is possible to determine the boron isotopic composition of diborane to within 1% on an ordinary single or double-beam spectrometer. No vibrations, which should become infrared-active in $B^{11}B^{10}H_6$ because of lowering of symmetry from $V_h$ to $C_{2v}$ were observed. Studies employing a grating infrared spectrometer permitted complete separation of $B_2^{11}$, $B^{11}B^{10}$, and $B_2^{10}$ peaks of $\nu_{14}$ and $\nu_{18}$ vibrations for diboranes containing 1.13, 18.83, 56.4, 73.5, and 96% $B^{10}$. The resolution was good enough to permit the estimation of the fractions of each of the species $B_2^{11}$, $B^{11}B^{10}$, and $B_2^{10}$ present in the samples. (auth)

**32080** SOME DECOMPOSITION EFFECTS IN $PuO_2$ ON SINTERING. B. Cina (Nuclear Materials and Equipment Corp., Apollo, Penna.). J. Nucl. Mater., 9: 85-100(June 1963). (In English)

$PuO_2$ pellets, prepared by cold compaction of $PuO_2$ powder derived from Pu(IV) oxalate, were sintered in various reducing, oxidizing, and inert atmospheres and in vacuo. Except during oxidizing conditions, some reduction of the $PuO_2$ to alpha $Pu_2O_3$ was observed in most cases after sintering at 1600°C. Where sufficient alpha−$Pu_2O_3$ was formed, the resulting two phase mixture was found in a eutectoid form. It is suggested that in these cases a single phase oxygen-deficient $PuO_2$ is formed at the sintering temperature and that this phase decomposes eutectoidally on cooling at about 650°C as follows: $PuO_{2-y} \rightarrow PuO_2 + \alpha\, Pu_2O_3$ where 2 − y was found to be as low as 1.80. The effect of the several sintering variables and the role of impurities on the above decomposition are reported. (auth)

**32081** SOME ELECTRIC AND MAGNETIC PROPERTIES OF RARE EARTH MONOSULFIDES AND NITRIDES. R. Didchenko and F. P. Gortsema (Union Carbide Corp., Parma, Ohio). J. Phys. Chem. Solids, 24: 863-70(July 1963). (In English)

Lanthanon monosulfides show semimetallic conductivities with the exception of EuS and YbS, which are insulators, and of SmS, which is an n-type semiconductor with an energy gap of 0.24 ev. Ytterbium monosulfide becomes a p-type semiconductor when doped with sulfur. A new value for the susceptibility of EuS is given. Rare earth nitrides have the same crystal structure (NaCl) but are not isoelectronic with the monosulfides, except for CeN in which cerium has an oxidation state of +4. Magnetic measurements revealed that in EuN there is present $Eu^{2+}$ in large amounts depending on the oxygen content; SmN and YbN also contain metal ions in +2 state. In all other nitrides of the series the metal is present as tripositive ion. All nitrides show semimetallic conductivity with the exception of YbN which appears to be a semiconductor. (auth)

**32082** THE ELECTRONIC STRUCTURE OF RARE EARTH MONOSULFIDES. J. W. McClure (Union Carbide Corp., Parma, Ohio). J. Phys. Chem. Solids, 24: 871-80 (July 1963). (In English)

A simple model for the electronic structure of the rare earth monosulfides, monoselenides and monotellurides is presented. The model correlates the magnetic susceptibility data with the type of electrical conductivity (metallic or n- or p-type semiconduction) observed. Rough quantitative agreement is obtained with conductivity, Hall effect, and thermoelectric power data. (auth)

**32083** NUCLEAR MAGNETIC RESONANCE IN METAL HEXABORIDES. Edward J. McNiff, Jr. and Sidney Shapiro (Arthur D. Little, Inc., Cambridge, Mass.). J. Phys. Chem. Solids, 24: 939-45(July 1963). (In English)

NMR investigations of a number of metal hexaborides were carried out at room temperature and a field of 5800 G. Both positive and negative Knight shifts were observed for the $B^{11}$ resonance. Magnetic polarization of the conduction electrons by the metal ion cores provides a basic explanation for the signs and magnitudes of the shifts in the paramagnetic hexaborides. In $LaB_6$, $CaB_6$, and $EuB_6$ the $B^{11}$ resonance frequency was observed to depend upon composition. These shifts were determined to be associated with alterations of the conduction electron density. However, the large diamagnetic shifts observed in metal-deficient samples of $CaB_6$ and $EuB_6$ could not be explained on the basis of any of the mechanisms suggested. (auth)

**32084** COHESIVE ENERGY OF THE ALKALI HALIDE CRYSTALS. Mario Tosi (Argonne National Lab., Ill.). J. Phys. Chem. Solids, 24: 965-7(July 1963). (In English). (TID-18383)

It is shown that the Born repulsive energy in the alkali halides at atmospheric pressure is represented better by a single exponential form than by the inverse power form. The role of the van der Waals energy and proper treatment

of the equation of state in the determination of the parameters entering the Born model expression for the lattice energy are elucidated. The values of the cohesive energy of the alkali halide crystals at room temperature and atmospheric pressure, calculated by the Born model in different approximations, and their deviations from the experimental values determined by a Born-Haber cycle in these thermodynamic conditions are presented. (C.E.S.)

**32085** STUDIES ON COORDINATION COMPOUNDS OF URANYL ACETATE WITH ORGANIC ACIDS. III. THE SYSTEM: URANYL ACETATE–BENZILIC ACID–WATER. C. S. Pande and S. K. Misra (Lucknow Univ., India). J. Prakt. Chem., 19: 330-6(Mar. 1963).

Conductometric and pH studies of the mixed solutions of uranyl acetate and sodium benzilate revealed the existence of one complex compound in (1 : 2) molecular ratio. The compound was isolated and its U content determined. (auth)

**32086** THERMODYNAMIC PROPERTIES OF MAGNESIUM OXIDE AND BERYLLIUM OXIDE FROM 298 TO 1200°K. Andrew C. Victor and Thomas B. Douglas. J. Res. Natl. Bur. Std., 67A: 325-9(July-Aug. 1963).

As a step in developing new standards of high-temperature heat capacity and in determining accurate thermodynamic data for simple substances, the enthalpy (heat content) relative to 273°K, of high purity fused magnesium oxide, MgO, and of sintered beryllium oxide, BeO, was measured up to 1,173°K. A Bunsen ice calorimeter and the drop method were used. The two samples of BeO measured had surface-to-volume ratios differing by a factor of 15 or 20, yet agreed with each other closely enough to preclude appreciable error attributable to the considerable surface area. The enthalpies found for MgO are several percent higher than most previously reported values. The values are represented within their uncertainty (estimated to average ±0.25%) by empirical equations. Values of enthalpy, heat capacity, entropy, and Gibbs free-energy function are tabulated from 298.15 to 1,200°K. (auth)

**32087** PREPARATION OF ANHYDROUS SINGLE CRYSTALS OF RARE-EARTH HALIDES. Norman H. Kiess. J. Res. Natl. Bur. Std., 67A: 343-5(July-Aug. 1963).

Anhydrous rare-earth halides are prepared by the conversion of the rare-earth oxide to the halide by means of its reaction with the appropriate ammonium halide. Without transfer from the reaction vessel, the halide is melted, then crystallized by slow cooling. The resulting solid usually contains single crystals large enough to permit spectroscopic studies of the compounds. (auth)

**32088** NEW PROTON-CONTAINING OXIDES OF TITANIUM, ZIRCONIUM AND HAFNIUM. F. K. McTaggart (CSIRO, Fishermen's Bend, Victoria, Australia). Nature, 199: 339-41(July 27, 1963).

Evidence was found suggesting that the golden oxides, $ZrO_2$, $HfO_2$, and $TiO_2$, contain H and may be related to the various metal oxide bronzes. The oxides of Ti, Zr, and Hf, either as powders, compacts, ceramic bodies, or layers on metal substrates, were all readily converted on their surfaces to the golden materials. During H treatment metals underlying the oxide layers became brittle due to the uptake of H and some N (weak lines of ZrN were observed in x-ray examinations of the metal layers in samples of Zr) and required careful handling. However, there was no evidence to suggest that N plays any part in the formation of the golden materials, and they certainly do not contain nitride. Analysis of the materials established the fact that they contain appreciable amounts of H, the formula of the Ti compound being $H_{0.2}Ti_{1.00}O_{1.3}$ and that of the Zr, $H_{0.2}Zr_{1.00}O_{1.66}$. All the golden oxides rapidly re-oxidize to white oxides when heated in air or O, and in most chemical properties bear a close resemblance to the dioxides. (P.C.H.)

**32089** THE MÖSSBAUER EFFECT IN CHEMICAL COMPOUNDS OF $Xe^{129}$. C. L. Chernick, C. E. Johnson, J. G. Malm, G. J. Perlow, and M. R. Perlow (Argonne National Lab., Ill.). Phys. Letters, 5: 103-4(June 15, 1963). (In English)

Measurements were made using the 40-kev $3/2^+ \rightarrow 1/2^+$ transition in $Xe^{129}$ with absorbers of $XeF_2$, $XeF_4$, a xenate having the nominal formula $Na_4XeO_6 \cdot H_2O$, and the hydroquinone clathrate of Xe containing 28% of Xe by weight. The clathrate and xenate show a single line unshifted from zero velocity while the fluorides exhibit large quadrupole splittings and no net isomer shift. The lifetime of the $3/2^+$ states was determined to be 0.58 ± 0.07 nsec. Evidence for a Xe valence of 8 was found in the xenate. Splitting in $XeF_2$ and $XeF_4$ was measured as 4.19 ± 0.11 cm/sec. (D.C.W.)

**32090** INVESTIGATIONS INTO THE ORIGIN OF THE CRYSTALLINE ELECTRIC FIELD EFFECTS ON RARE EARTH IONS. II. CONTRIBUTIONS FROM THE RARE EARTH ORBITALS. D. K. Ray (Oxford Univ.). Proc. Phys. Soc. (London), 82: 47-57(July 1963).

Within the limitations of the ionic approximation, different contributions to the crystalline electric field parameters arising from the orbitals of the rare earth ions are calculated with particular reference to the $Pr^{3+}$ ion in $PrCl_3$. Contributions from the neighboring point charges of both rare earth and ligand ions as well as those from the induced moments of the ligand ions were earlier considered by Hutchings and Ray in 1963. Rare earth orbitals, on the other hand, affect the crystalline electric field in three different ways arising from multipole electric moments of the f electrons in the externally impressed crystalline potential, induced moments on the closed s, p, and d shells caused by the surrounding charges, and shielding of the external crystal field at the 4f electrons by the distorted orbitals. The first two factors are associated with the effect of rare earth orbitals of one ion on the crystalline electric field at another ion, whereas the last effect is concerned with the extra potential produced by the closed orbitals of the same ion for which the crystalline field parameters are being evaluated. The first factor is shown to contribute negligibly to the crystalline electric field parameters, whereas the effect of induced moments is of importance only for the $A_2^0$ term. The general expression for the shielding of any crystal potential term was derived and is shown to be independent of m. Numerical estimation of the shielding was made for the $A_2^0$ term and is found to reduce the external crystal field value by 52%, thus bringing the previously calculated value of $A_2^0\langle r^2\rangle$ closer to the experimental one. The nuclear antishielding factor $\gamma_\infty$ is calculated for the $Pr^{3+}$ ion, and on the basis of the point charge value of crystal potential, the expected quadrupolar frequency of nuclear magnetic resonance lines is evaluated for $La^{3+}$ in $LaCl_3$. This value is shown to be in excellent agreement with the one experimentally observed recently by Edmonds. Implications of the results are discussed and further improvements in the method of calculations were suggested. (auth)

**32091** SELECTIVE POPULATING OF ZEEMAN LEVELS IN ALKALI METAL ATOMS. [PART] II. N. J. Ionescu-Pallas and V.-G. A. Velculescu (Inst. of Atomic Phys., Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 47-58(1963). (In French)

The effects of collisions on the thermal mixing of atomic spin levels in excited states of alkali-metal atoms are studied. The separation in energy is sufficiently small, in the case of the resonance doublet in these atoms, that the probability for energy transfer by shocks of the second kind is appreciable at the temperatures required in order that a vapor pressure exist that is high enough for a signal to be detected. Polarized and unpolarized emission is considered, and the case of Na is considered numerically. (T.F.H.)

**32092** CONTRIBUTION TO THE STUDY OF THE USE OF ORGANIC SOLVENTS IN CATION EXCHANGE. M. Constantinescu, O. Constantinescu, E. Gîrd, A. Ruşi, C. Sabău, St. Spiridon, and S. Ionescu (Inst. of Atomic Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 143-50(1963). (In French)

For exchange of trivalent Ce, Pr, and Sc ions on the cation exchange resin KU-2, the variations of the distribution coefficients ($K_d$) with the concentrations of organic solvent and HCl are measured. It is found that $K_d$ increases with increasing solvent content. Relations are found between the quantity of ions adsorbed, the acid concentration, and the nature and concentration of the organic solvent. The exchange dynamics of $Ce^{3+}$ are followed in various concentrations of HCl, acetone, and water. (T.F.H.)

**32093** URANYL ION COORDINATION. Howard T. Evans, Jr. (Geological Survey, Washington, D. C.). Science, 141: 154-8(July 12, 1963).

A review of the known crystal structures containing the uranyl ion showed that plane-pentagon coordination is equally as prevalent as plane-square or plane-hexagon. It is suggested that puckered-hexagon configurations of $OH^-$ or $H_2O$ about the uranyl group will tend to revert to plane-pentagon coordination. The concept of pentagonal coordination is invoked for possible explanations of the complex crystallography of the natural uranyl hydroxides and the unusual behavior of polynuclear ions in hydrolyzed uranyl solutions. (auth)

**32094** THE ELECTRODE PROPERTIES AND CHEMICAL STABILITY OF LITHIUM SILICATE GLASSES CONTAINING OXIDES OF YTTRIUM. A. I. Parfenov, M. M. Shults, T. N. Nekrasova, and I. P. Polozova. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 126-34 (1963). (In Russian)

The electrode behavior and chemical stability of lithium-silicate glasses which contain $La_2O_3$, $Nd_2O_3$, $Y_2O_3$, and $CeO_2$ were studied. The introduction of these oxides into the glasses is shown to favor the extension of the limits of pH function to the acid region and increase the chemical stability of glasses. (auth)

**32095** THE INFLUENCE OF $ZrO_2$ ON ELECTRODE PROPERTIES AND CHEMICAL STABILITY OF ALKALI SILICATE GLASSES. M. M. Shults, A. I. Parfenov, and N. P. Panfilova. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 143-8(1963). (In Russian)

The influence of $ZrO_2$ on the electrode properties and chemical stability of $Li_2O-SiO_2$ glasses was studied. The introduction of $ZrO_2$ into these glasses is shown to shorten the range of pH function but to increase the chemical stability of electrode glasses. (auth)

**32096** THE ELECTRODE PROPERTIES OF GLASSES OF THE $Li_2O-Cs_2O-La_2O_3-SiO_2$ OXIDE SYSTEM. M. M. Shults, A. I. Parfenov, Tieh-yü Ch'en, T. G. Bondarenko, and J. J. Mekhrjushev. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 155-60(1963). (In Russian)

The electrode properties of glasses of the $Li_2O-Cs_2O-La_2O_3-SiO_2$ system were investigated. Summation of the effects of the oxides $Cs_2O$ and $La_2O_3$ in the electrode behavior of glasses is shown. (auth)

**32097** THE INVESTIGATION OF ELECTRODE PROPERTIES AND CHEMICAL STABILITY OF LITHIUM SILICATE GLASSES, CONTAINING BaO AND $La_2O_3$. M. M. Shults, N. V. Peshekhonova, and T. V. Lipets. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 160-2 (1963). (In Russian)

The electrode behavior and chemical stability of glasses of the $Li_2O-BaO-La_2O_3-SiO_2$ system were investigated. The summation of the effects of BaO and $La_2O_3$ oxides in the electrode behavior of glasses was shown. (auth)

**32098** THE ELECTRODE PROPERTIES AND CHEMICAL STABILITY OF A NUMBER OF POLYCOMPONENT LITHIUM SILICATE GLASSES. A. I. Parfenov, M. M. Shults, N. N. Kochergina, V. P. Ivanov, S. B. Evnina, L. P. Kalmykova, and E. D. Ageeva. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 162-6(1963). (In Russian)

The electrode behavior and chemical stability of glasses of the system $Li_2O-Cs_2O-BaO-La_2O_3-SiO_2$ were investigated at 20, 95, and 150°C. The influence of introduction of the oxides $TiO_2$, $ZrO_2$, and $ThO_2$ on the properties of these glasses was shown. (auth)

**32099** POLAROGRAPHY OF CERIUM IN LITHIUM SULPHATE. O. P. Agrawal and R. C. Kapoor (Univ. of Allahabad, India). Z. Anorg. Allgem. Chem., 318: 59-62 (Sept. 1963). (In English)

Ammonium hexanitratocerate and ceric ammonium sulfate give two waves in 0.1 M lithium sulfate. The first wave starts at zero applied potential and represents the reduction of Ce(IV)–Ce(III). The second wave, which is also diffusion controlled, has a $E_{1/2}$ value of 1.57 v vs a standard calomel electrode. The limiting current of the second wave is 12 to 14 times that of the first wave. It was proposed that the second wave is either due to reduction of aquo cerium complex or that Ce(III) initiates reduction of water around the mercury drop. It is not due to the reduction of Ce(III) to Ce(metal). (auth)

**32100** ON TERNARY OXIDES OF NIOBIUM AND TANTALUM OF THE TYPE $ABO_4$. C. Keller (Technische Hochschule, Karlsruhe, Ger. and Kernforschungszentrum, Karlsruhe, Ger.). Z. Anorg. Allgem. Chem., 318: 89-106 (Sept. 1962). (In German)

The preparation of ternary oxides of niobium and tantalum of the $ABO_4$-type having fergusonite, wolframite, stibiotantalite, and rutile structures is reported. $LaNbO_4$, $YNbO_4$, all niobates of the rare earths, $YTaO_4$, and the rare-earth tantalates of Nd–Er crystallize in the fergusonite structure. No gadolinium corner was detected either in the niobates or in the tantalates of rare earths. Apart from $FeNbO_4$, the niobates and tantalates of indium and scandium have wolframite structure. $SbTaO_4$ and $SbNbO_4$ show stibiotantalite structure. The double oxides of niobium and tantalum with Rh, Ti, V, Cr, and Fe crystallize in the rutile lattice. Lattice constants of the 42 ternary oxides mentioned are quoted and their structures are discussed. (auth)

**32101** FERROCYANIDE COMPLEXES OF ZIRCONIUM. J. N. Gaur (Univ. of Rajasthan, Jaipur, India). Z. Anorg. Allgem. Chem., 318: 323-7(Nov. 1962). (In English)

The reactions between zirconyl chloride and potassium ferrocyanide were studied by analytical methods including potentiometric and conductometric titrations. The complex $(ZrO)_2[Fe(CN)_6]$ is formed when the two solutions are mixed even in very dilute solutions. This complex, when

dried at 60°C, has the composition of $(ZrO)_2[Fe(CN)_6] \cdot 2\,H_2O$; at 200°C, $(ZrO)_2[Fe(CN)_6]$ is obtained; higher temperature leads to decomposition. If to the zirconyl chloride solution excess concentrated HCl is added, then the complex $Zr[Fe(CN)_6] \cdot 8\,H_2O$ is formed giving $Zr[Fe(CN)_6] \cdot 2\,H_2O$ at 200°C above which the complex decomposes. (auth)

**32102** ON THE CHROMATES(V) OF THE RARE EARTHS. I. LANTHANUM CHROMATE(V), $LaCrO_4$. H. Schwarz (Technische Hochschule, Karlsruhe, Ger.). Z. Anorg. Allgem. Chem., 322: 1-14(May 1963). (In German)

During the thermal decomposition of lanthanum chromate(VI), yielding finally $LaCrO_3$ and $Cr_2O_3$, $LaCrO_4$ is intermediately formed. The preparation and properties of pure dark green $LaCrO_4$ are described. Its structure (huttonite type) is compared with analogous compounds of $P^V$, $As^V$, and $V^V$. Attempts to prepare Ce(III) chromate(V) failed. (auth)

**32103** ON THE CHROMATES(V) OF THE RARE EARTHS. II. PRASEODYMIUM CHROMATE(V), $PrCrO_4$. H. Schwarz (Technische Hochschule, Karlsruhe, Ger.). Z. Anorg. Allgem. Chem., 322: 15-24(May 1963). (In German)

$Pr^VCrO_4$ was formed by thermal decomposition of $Pr_2(CrO_4)_3$ as an intermediate product or, in almost pure state, by interaction between praseodymium chromate(VI) and nitrate. Two modifications occurred: the huttonite and zircon types. The lattice constants of the zircon type structure are discussed and compared with those of the isotypic $PrVO_4$. (auth)

**32104** ON THE CHROMATES(V) OF THE RARE EARTHS. III. NEODYMIUM CHROMATE(V), $NdCrO_4$. H. Schwarz (Technische Hochschule, Karlsruhe, Ger.). Z. Anorg. Allgem. Chem., 322: 129-36(May 1963). (In German)

In the course of the thermal decomposition of $Nd_2(CrO_4)_3$, yielding finally $Nd^{III}CrO_3$ and $Cr_2O_3$, $Nd^VCrO_4$ was intermediately formed. The preparation and properties of pure dark green $NdCrO_4$ are described. The lattice constants of $NdCrO_4$ and $NdVO_4$ (both being of zircon type) are discussed. (auth)

**32105** ON THE CHROMATES(V) OF THE RARE EARTHS. IV. YTTRIUM CHROMATE(V), $YCrO_4$. H. Schwarz (Technische Hochschule, Karlshrule, Ger.). Z. Anorg. Allgem. Chem., 322: 137-44(May 1963). (In German)

The thermal decomposition of $Y(OH)Cr^{VI}O_4$ above 700°C led to $YCr^{III}O_3$ with a rhombically distorted perovskite structure. As an intermediate, $YCr^VO_4$ was formed. Some properties of this compound are described. Like $YPO_4$, $YAsO_4$, and $YVO_4$, it has zircon structure. The unit cell dimensions of these compounds are given together with those of $CaCr^{VI}O_4$. (auth)

**32106** ISOTOPIC EFFECT IN THE MAGNITUDE OF THE VOLUMES OF NITROGEN ISOTOPES UNIT CELLS. V. S. Kogan and T. G. Omarov (Inst. of Physics and Tech., Academy of Sciences, Ukrainian SSR). Zh. Eksperim. i Teor. Fiz., 44: 1873-5(June 1963). (In Russian)

The lattice parameters of nitrogen isotopes are determined at 20°K. The relative change of the unit cell volume as a function of relative change of the nitrogen isotope masses can be described by the same linear dependence as that for the isotopes of other molecular gases. The slope of the line for the isotopes of atomic gases (Ne and He) is apparently greater than that for molecular gases. (auth)

**32107** RESONANCE ABSORPTION OF γ-QUANTA IN BARIUM, STRONTIUM AND CALCIUM STANNITES. Fam Zui Khien, V. S. Shpinel, A. S. Viskov, and Yu. N. Venevtsev (Moscow State Univ. and Karpov Inst. of Physics and Chemistry, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1889-95(June 1963). (In Russian)

The parameters of the spectra of resonance absorption of 23.8-kev γ quanta emitted by the $Sn^{119*}$ nucleus in barium, strontium, and calcium stannites belonging to a single structural type of perovskite are measured at temperatures between 78 and 1020°K. The dependence of the probability of recoilless absorption and of the resonance energy shift on temperature is investigated. A peculiar temperature dependence of the spectra widths, which is similar in all studied compounds, is detected. The temperature dependences of the elementary cell periods are measured at 293 to 893 and 293 to 843°K for barium and strontium stannites respectively. The effect of differences in atomic masses and parameters of the elementary cells on the measured quantities and the possible mechanism of variation of the width and shape of the absorption spectrum are discussed. (auth)

**32108** CLASSIFICATION OF HYDRIDES. G. V. Samsonov (Inst. of Metal Ceramics and Special Alloys, Academy of Sciences, Ukrainian SSR). Zh. Neorgan. Khim., 8: 1320-5(June 1963). (In Russian)

An analysis was made of published data on hydrides and the following classifications are suggested: 1. Ion- or salt-forming hydrides formed by non-transitional metals with external S electrons of first ionization potential from 3 to 7 ev (alkali hydrides and alkali earth metals except Be and Mg). 2. Metal hydrides of d- and f-transition metals; 3. Covalent-metal hydrides (or intermediate) formed by non-transitional metals with S-electron of first ionization potential from 7 to 11 ev (I b and II b subgroup metal hydrides including Be and Mg); 4. Covalent hydrides formed by non-transitional elements with external p-electrons independent of ionization potentials. (R.V.J.)

**32109** THERMAL DECOMPOSITION OF SAMARIUM HYDROXIDES AND TETRAVALENT CERIUM. M. N. Ambrozhii and L. M. Dvornikova (Saratov State Univ., USSR). Zh. Neorgan. Khim., 8: 1345-54(June 1963). (In Russian)

Thermographic studies of thermal decomposition of $Sm_2O_3$ and tetravalent cerium showed that the composition of freshly prepared samarium hydroxides and tetravalent cerium at normal temperatures is $Sm(OH)_3 \cdot H_2O$ and $Ce(OH)_4 \cdot H_2O$ respectively. A separation of water and formation of hydroxides $Sm(OH)_3$ and $Ce(OH)_4$ takes place at 100°C. (R.V.J.)

**32110** SPECTROPHOTOMETRIC STUDIES OF SAMARIUM(III) AND EUROPIUM(III) COMPLEX FORMATION WITH DIETHYLENETRIAMINEPENTAACETIC ACID. Yu. P. Galaktionov and K. V. Astakhov (Moscow Inst. of Fine Chemical Tech.). Zh. Neorgan. Khim., 8: 1395-9(June 1963). (In Russian)

Spectrophotometric studies were made of complex formation of $Sm^{2+}$ and $Eu^{3+}$ with diethylenetriaminepentaacetic acid in aqueous solutions. It is shown that $Sm^{2+}$ and $Eu^{3+}$ with DTPA form complexes: $Me_2X^+$(pH 0.9 to 1.3), $MeX^{2-}$(pH 1.3 to 1.9) and $MeHX^1$ (latter for $Sm^{3+}$ only). Acidolysis and stability constants of formed complexes were determined. (R.V.J.)

**32111** REACTIONS OF $CeO_3$, $Nd_2O_3$, AND $Sm_2O_3$ WITH MOLTEN FLUORIDES. S. I. Berul and N. K. Voskresenskaya (Kurnakov Inst. of General and Inorganic Chemistry,

Academy of Sciences, USSR). Zh. Neorgan. Khim., 8: 1431-6(June 1963). (In Russian)

Isothermal studies of $CeO_2$, $Nd_2O_3$ and $Sm_2O_3$ reactions with eutectic mixture NaF–KF, cryolites, and eutectic mixtures of cryolite and sodium fluoride showed that 0.1 wt % Ce and 0.7 to 0.7 wt % Sm diffuse into NaF–KF mixture after 4 hours at 1000 to 1100°C. Eutectic diagrams indicate 5.5 mole % $CeO_2$ at 880°C and 1.2 mole % $Sm_2O_3$ at 963°C. The liquidus system of $Na_3AlF_6$–$Nd_2O_3$ exhibits eutectics at 12 mole % $Nd_2O_3$ at 904°C. Endothermal reactions were observed in non-melted $Na_3AlF_6$–$Sm_2O_3$ mixtures. At 798°C 22 mole % $CeO_2$ dissolves in the $Na_3AlF_6$–NaF mixture. (R.V.J.)

**32112** THE RECIPROCAL TERNARY SYSTEM FORMED BY THE BROMIDES AND NITRATES OF SODIUM AND BARIUM. M. A. Zakharchenko and S. M. Mkrtchyan (Inst. of Agricultural Machine Construction, Chair of General Chemistry, Rostov-on-the-Don, USSR). Zh. Neorgan. Khim., 8: 1450-2(June 1963). (In Russian)

The bromide–nitrate reciprocal mixtures represent a relatively poorly investigated area of the molten salt chemistry. The irreversibly reciprocal Na, Ba :: Br, $NO_3$ was examined by thermal methods, using heat-resistant glass containers; the mixtures were melted in an electric furnace, employing Ni–constantan thermocouples for the temperature measurements. It was found that the stable diagonal $Na_2Br_2$–$Ba(NO_3)_2$ divides the reciprocal system in 2 triangular phase diagrams: $Ba(NO_3)_2$–$(NaNO_3)_2$–$Na_2Br_2$ and $Ba(NO_3)_2$–$Na_2Br_2$–$BaBr_2$. The systems have a nonvariant eutectic point at 278 and 400°C. The binary system $Ba(NO_3)_2$–$BaBr_2$ forms a eutectic mixture of 506°C and 39% $BaBr_2$. (TTT)

**32113** THE RECIPROCAL SYSTEM FORMED BY THE CHLORIDES AND THE BROMIDES OF LITHIUM AND THALLIUM. A. G. Bergman and A. S. Arabadzhan (Scientific Research Inst. of Machine Construction, Rostov-on-the-Don, USSR). Zh. Neorgan. Khim., 8: 1453-4(June 1963). (In Russian)

The phase diagrams of 2 series of continuous solid solutions, the Li, K :: Cl, Br and the Li, Tl :: Cl, Br were investigated, as part of a study of the relation between thermal effect of equilibrium reactions and the structure of the melts. In the second system, the heat of the exchange reaction LiCl + TlBr ⇌ LiBr + TlCl amounts to 6.19 kcal/mole, being larger than that of the corresponding reaction in the Li, K :: Cl, Br system; this affects the crystallization surface in the system. A Pt crucible and Pt, Au, Pd/Pt–Rh thermocouple were used in the thermal studies. It was found that the liquidus surface consists of 2 fields of continuous series of solid solutions. The joint crystallization curve has a maximum at 392°C at the stable portion of the LiCl–TlBr system. There is crest in the liquidus surface corresponding to the stable diagonal LiCl–TlBr; this is visible more markedly in the Li(Cl, Br) field. (TTT)

**32114** THE RECIPROCAL SYSTEM OF SODIUM AND POTASSIUM PYROPHOSPHATES AND FLUORIDES. A. G. Bergman, K. F. Kaznacheeva, V. P. Goryacheva, and A. P. Sadovskii (Scientific Research Inst. of Machine Construction, Rostov-on-the-Don, USSR). Zh. Neorgan. Khim., 8: 1455-60(June 1963). (In Russian)

The mutual systems containing K and Na salts of the more complex anions are of special interest because they tend to precipitate out as a continuous system of solid solutions which in turn, upon cooling decompose and form specific compounds. The Na, K :: $P_2O_7$, F represents a face of the previously studied quaternary phase diagram, containing also Li. Thermal analysis and x-ray diffraction were used in the study of the system. In the binary system $K_4F_4$–$K_4P_2O_7$ two incongruently melting compounds were found; they had the following composition: $3K_4F_4 \cdot K_4P_2O_7$ and $K_4F_4 \cdot 4K_4P_2O_7$($KF \cdot K_4P_2O_7$) extending from the side of the diagram to the area of crystallization of NaF. With decreasing temperature, the solid solutions of the $Na_4P_2O_7$–$K_4P_2O_7$ system decompose by the fluorides, forming the compound $3Na_4P_2O_7 2K_4P_2O_7$. The system is irreversibly reciprocal, having a stable diagonal of $Na_4F_4$–$K_4P_2O_7$. The area of the stable component NaF is adjacent to all the components and compounds. (TTT)

**32115** SOLUBILITY OF $Sc(NO_3)_3 \cdot 4H_2O$ AND $ScOH(NO_3)_2 \cdot 3H_2O$ IN WATER, NITRIC ACID AND ORGANIC SOLUTIONS. G. Ya. Pushkina and L. N. Komissarova (Moscow State Univ.). Zh. Neorgan. Khim., 8: 1498-1504(June 1963). (In Russian)

The solubility of $Sc_2O_3$–$HNO_3$–$H_2O$ was examined by the isothermal method at 25°C and 3.4 to 71.2 wt % $N_2O_5$ concentrations. Various donor phases were found on the basis of $HNO_3$ concentrations: scandium with adsorbed $HNO_3$(3.4 to 25.4 wt % $N_2O_5$), basic nitrate $ScOH(NO_3)_2 \cdot 3H_2O$ (with 25.38 to 43.35 wt % $N_2O_5$), and normal nitrate $Sc(NO_3)_3$ $4H_2O$ (with 43.95 to 71.22 wt % $N_2O_5$). The solubility of $Sc(NO_3)_3 \cdot 4H_2O$ and $ScOH(NO_3)_2 \cdot 3H_2O$ was examined at 0 to 50 and 15 to 90° respectively, and pH and electroconductivity of the above compounds were determined at 0.001 to 1.0 mole/l concentrations. It was revealed that the best solvent properties are found with polar solvents resulting in $Sc(NO_3)_3 \cdot 4H_2O$ solubility series: simple ethers < complex ethers < alcohols < ketones. (R.V.J.)

**32116** THE VAPOR PRESSURE OF ZIRCONIUM TETRAFLUORIDE. P. A. Akishin, V. I. Belousov, and L. N. Sidorov. Zh. Neorgan. Khim., 8: 1520-2(June 1963). (In Russian)

The data reported in the literature on the absolute vapor pressure and the heat of sublimation of $ZrF_4$, obtained by dynamic and static methods, do not agree well with each other; therefore, a new determination was made, using a mass spectrographic method. The preparation used for the test contained less than 2% of Zr oxyfluoride. Up to a temperature of 1000°K, $HF^+$, $F^+$, and $Na^+$ ions were also found in the system, in addition to the ions formed from $ZrF_4$, at the ration of 1 ion to 3000 $ZrF_3^+$ ions. At 1300°K the $ZrOF_2^+$ was observed in the mass spectrum; its vapor pressure was estimated at about $10^{-3}$ mm of Hg. The vapor pressure of $ZrF_4$ at 875 and 836°K was found to be $4.08 \times 10^{-1}$ and $5.28 \times 10^{-2}$ mm of Hf, respectively. On the basis of the previously established heat of sublimation, the vapor pressure of $ZrF_4$ within the temperature range from 681 to 913°K may be expressed by: $\log p = 13.5571 - (12430)/(T)$. The error is estimated at less than 2% if 3 to 5 mg of the material are used for the measurements. The values found lie between those reported by K. A. Sense et al. (J. Phys. Chem. 58, 995 (1944)) and S. Cantor et al. (J. Phys. Chem. 62, 96 (1958)). (TTT)

**32117** THERMAL DECOMPOSITION OF CERIUM FERROCYANIDES. G. B. Seifer. Zh. Neorgan. Khim., 8: 1525-6(June 1963). (In Russian)

A thermal decomposition of normal cerium ferrocyanide $Ce_4[Fe(CN)_6]_3$ was examined by thermographic method and by weight and chemical analysis of decay products. The thermal decomposition of cerium ferrocyanide omits the $Ce_2(CN_2)_3$ stage of formation due to the catalytic effects in the residual iron cyanide. A thermogram of $Ce_4[Fe(CN)_6]_3 \cdot 14.5\ H_2O$ exhibiting gas emission and weight loss curves

is included, and various effects on the thermogram are analyzed.

**32118** EVAPORATION OF RARE EARTH TETRACHLORIDES. O. G. Polyachenok and G. I. Novikov (Leningrad State Univ.). Zh. Neorgan. Khim., 8: 1526-7(June 1963). (In Russian)

Thermodynamic characteristics of saturated vapor pressures in $LaCl_3$, $CeCl_3$, $PrCl_3$, $NdCl_3$, and EuCl were measured up to 1400°C by thermographic "boiling point" variation method. The results are described by the equation: $lg p_{mmHg} = A - \beta/T - 9.061 \lg T$ where coefficient 9.061 is $(\Delta Cp)/(R)$ (where $\Delta Cp = -18 \pm 2$ kcal/mole). The equation holds from melting point up to boiling point of all respective rare earth chlorides. Characteristics of evaporation process are tabulated Ce, Dy, Er, Eu, Ga, Ho, La, Lu, Nd, Pm, Pr, Tb, Tm, Yb tetrachlorides. (R.V.J.)

**32119** COMPLEX PENTAACID–URANYL OXALATE–HALIDE COMPOUNDS. I. I. Chernyaev and R. N. Shchelokov (Kurnakov Inst. of General and Inorganic Chemistry, Academy of Sciences, USSR). Zh. Neorgan. Khim., 8: 1530-1(June 1963). (In Russian)

Intraspheric replacement of $[UO_2(C_2O_4)_2\ (H_2O)_2]^{2-}$ aquo groups by $Cl^-$, $Br^-$, and $I^-$ ions was studied considering a much weaker than oxalate bond between the addend ions and uranyl ions. The competition between the aquo and halide groups in the replacement reaction was taken into account in the synthesis of mixed uranyl oxalate–halide compound: $UO_2(C_2O_4)_2\ (H_2O)_2^{2-} + nX^- + mH_2O \rightleftharpoons [UO_2(C_2O_4)_2\ X(H_2O)]^{3} + (n-1)\ X^- + (m+1)H_2O$. Formation of aquo oxalate compounds of pentaacid series (derivatives of complex anion $[(UO_2)_2(C_2O_4)_5(H_2O)_2]^{6-}$) showed a great dependence on the external cation. A guanidine ion $CN_3H_6^+$ ion was selected as cation precipitator. It is shown that an intraspherical replacement of water molecules and formation of mixed dioxalate–chloride complex $(CN_3H_6)_3\ UO_2(C_2O_4)_2\ Cl$ take place under the chloride guanidine effects on $(CN_3H_6)_2\ [UO_2(C_2O_4)_2\ (H_2O)_2]$. A table of crystal refractive indices is given for guanidine derivatives of uranyl dioxalate halide series and initial guanidine diaquodioxalate uranylate. (R.V.J.)

**32120** THE TERNARY SYSTEM CONTAINING THE CHLORIDES OF LITHIUM, SODIUM AND BARIUM. M. A. Zakharchenko and S. M. Aslanov (Inst. of Agricultural Machine Construction, Chair of General Chemistry, Rostov-on-the-Don, USSR). Zh. Neorgan. Khim., 8: 1532-4(June 1963). (In Russian)

In view of the growing practical importance of systems containing the chlorides of alkali and alkaline-earth metals, the ternary melt of Li, Na, and K chlorides was investigated by the thermal method, using Pt–Rh thermocouples. The results were expressed in equivalent percentages. The $Li_2Cl_2$–$BaCl_2$ system was found to contain a eutectic point at 512°C and 40% $BaCl_2$, the $BaCl_2$–$Na_2Cl_2$ system had another eutectic point at 654°C and 57% $BaCl_2$. In the previously well investigated $Li_2Cl_2$–$Na_2Cl_2$ system, solid solutions are formed, with a minimum at 552°C and 27% NaCl. The ternary system was found to contain 5 component crystallization fields, including the compounds of LiCl·NaCl and LiCl · 2NaCl. The fields converge in 3 ternary nonvariant points, including 2 transition and one eutectic points. (TTT)

**32121** LANTHANUM TELLURIDES. E. I. Yarembash, E. S. Vigeileva, A. A. Eliseev, and L. I. Antonova. Zh. Neorgan. Khim., 8: 1542-3(June 1963). (In Russian)

Electrophysical properties of LaTe were studied, and conditions of lanthanum telluride preparation and phase compositions of La and Tl reactions are analyzed. Thermal synthesis of five-crushed La and Tl in presence of small quantities of iodine and $LaH_2$ with tellurium vapor produced phases of La–Te, $La_2Te_3$, and $LaTe_3$. In a NaCl-type lattice LaTe crystallized with a parameter $\alpha = 6.407 \pm 0.005$ kX. All prepared specimens (except ditelluride) possess n-type conductivity. (R.V.J.)

**32122** ON SOLID RUTHENIUM TETRACHLORIDE. H. I. Kolbin, A. N. Ryabov, and V. M. Samoilov. Zh. Neorgan. Khim., 8: 1543-5(June 1963). (In Russian)

Solid ruthenium tetrachlorides were prepared by condensation on liquid air cooled ruthenium chloride and $Cl_2$ vapor produced by $RuCl_3$ heating in chlorine current at 750°C. The temperature of $RuCl_4$ decomposition was found at –30°C. (R.V.J.)

**32123** STRUCTURE OF THE POLYANIONS OF THE TRANSITION METALS IN AQUEOUS SOLUTION: THE HEXATANTALATE. Wilfred H. Nelson and R. Stuart Tobias (Univ. of Minnesota, Minneapolis). 29p. (CONF-14-12)

From American Chemical Society National Meeting, Los Angeles, Mar.-Apr. 1963.

The synthesis of $K_8Ta_6O_{19} \cdot 16H_2O$ is described. Spectrophotometric, emf, and light-scattering studies are made of alkaline solutions of this compound, in which the Ta exists as Ta(V). The protonation of the compound in KOH solutions at pH of 10 to 13 is studied. (T.F.H.)

**32124** POLYMORPHISM OF $ABO_3$-TYPE RARE EARTH BORATE SOLID SOLUTIONS. R. S. Roth, J. L. Waring, and E. M. Levin (National Bureau of Standards, Washington, D. C.). 20p. (CONF-20-8)

From 3rd Rare Earth Conference, Clearwater, Fla., Apr. 1963.

Polymorphic relations of solid solutions of the $ABO_3$-type rare earth borates were studied by means of quenching techniques and high temperature x-ray diffraction. It was found that the polymorph reported as the high temperature form of $NdBO_3$ is only metastable and is formed, on cooling, from a phase isostructural with H-$LaBO_3$. The similar polymorph of $SmBO_3$ is apparently stable from room temperature to about 1065°C. The high vaterite form H-$SmBO_3$ is stable from about 1065 to 1285°C and the H-$LaBO_3$ type from 1285°C to the melting point. Phase equilibrium diagrams were constructed for the systems involving $LaBO_3$ with many of the other $RBO_3$ compounds and for $NdBO_3$–$SmBO_3$. The aragonite and vaterite type structures are not stable in the central portion of most of these systems. Instead, the H-$LaBO_3$ and L-$SmBO_3$-type phases appear as the stable polymorphs. The H-$LaBO_3$-type polymorph is a low symmetry distortion of a calcite type structure. As smaller ions are added in solid solution to $LaBO_3$ the distortion becomes less until with $LaLu(BO_3)_2$ an hexagonal phase is formed that may have a dolomite type structure, although the super-structure peaks are not evident. However, this phase apparently disorders to a H-$LaBO_3$ type solid solution rather than to the true calcite type structure. Although the temperature of the high-low inversion of the vaterite-type structures is lowered by the addition of $LaBO_3$ in solid solution, in no case was the high-vaterite structure obtained at room temperature. (auth)

**32125** OBSERVATIONS ON $M_3X_4$–$M_2X_3$ CRYSTALLINE PHASES OF RARE-EARTH TELLURIDES, SELENIDES, AND SULFIDES. J. F. Miller, L. K. Matson, and R. C. Himes (Battelle Memorial Inst., Columbus, Ohio). 13p. (CONF-20-11)

From 3rd Rare Earth Conference, Clearwater, Fla., Apr. 1963.

Study was made of the $M_3X_4-M_2X_3$ composition range in the subject systems in which the bcc $Th_3P_4$-type structure ($D7_3$) was usually observed to prevail. Some new crystal-structure data are presented for several rare-earth selenides and tellurides in this composition range. The structure of $Gd_2Te_3$, which previously was not known with certainty, was indexed as orthorhombic through studies on single-crystal specimens. A similar structure, with a slightly larger unit cell, was observed for specimens of $Nd_2Te_3$. Available crystal-structure data on the $M_3X_4-M_2X_3$ sulfides, selenides, and tellurides of the rare-earth elements are analyzed as they relate to the character of the bonding that prevails, the ranges of stability of the crystalline phases, and the electrical and other physical properties of the materials. (auth)

**32126** OBSERVATION ON RECRYSTALLIZATION OF $UO_2$ AT HIGH TEMPERATURE. M. Yunus (CEN, Grenoble, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/16, 27p. (CONF-120-1). (In French)

From conference of New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Tests were carried out in an apparatus in which a cylindrical stack of sintered $UO_2$ pellets can be axially heated by means of a W wire. In experiments under controlled temperature conditions, it was shown, in particular, that the transformation of equi-axed grains into basaltic grains begins at 1700°C. (auth)

**32127** THE OXIDATION OF URANIUM MONOCARBIDE IN CARBONIC ANHYDRIDE AT HIGH TEMPERATURES. R. Desrues, J. Paidassi, and R. Darras (CEN, Saclay, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/8, 49p. (CONF-120-6). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Samples of UC manufactured by two different techniques and a 96.7% U and 3.3% C (by weight) cermet were exposed to very carefully purified $CO_2$ in O and in $H_2O$ vapor in the temperature range 350 to 600°C; oxidation was observed gravimetrically (Eyraud thermobalance) and micrographically. The curves of weight increase start by being more or less linear, but climb rapidly, mainly because of the progressive fragmentation of the samples. The presence of U or dicarbide inclusions in the monocarbide decreased its resistance to oxidation; this was attributed mainly to the fact that they undergo very severe oxidation. In all cases oxidation may be characterized by an activation energy of 29,000 cal/mole; very close to the value for the oxidation of metallic U in the same gas. (P.C.H.)

**32128** SOME CHEMICAL FACTORS INFLUENCING THE THERMAL OXIDATION OF NUCLEAR GRAPHITE. J. B. Lewis, P. Conner, T. J. Dix, P. Hawtin, and R. Murdoch (Atomic Energy Research Establishment, Harwell, Berks, Eng.). 7p. (CONF-73-4)

From Biennial Conference on Carbon, Pittsburgh, June 1963.

Results are reported of experiments on the oxidation of graphite. Graphite specimens containing different contents of catalytic impurities were oxidized in air at 550 and 650°C; no correlation was found between the reaction rates or activation energies and the impurity content. The effects of moisture content of air on the oxidation were also studied. The surface area of graphite was found to increase with the burnoff. The order of the reaction with respect to the partial pressure of $O_2$ was determined to be 0.6th order. Oxidation of $CO_2$ and $N_2$ diluents indicated that $CO_2$ has no effect on the rate, but preheating in $CO_2$ and CO, but not $N_2$, increases the rate. (D.L.C.)

**32129** USE OF THE NUCLEAR OVERHAUSER EFFECT IN THE ANALYSIS OF HIGH RESOLUTION NUCLEAR MAGNETIC RESONANCE SPECTRA. Reinhold Kaiser (Univ. of New Brunswick, Fredericton, Can.). 10p. (CONF-76-1).

From Symposium on Molecular Structure and Spectroscopy, Columbus, Ohio, June 1963.

Relative intensity changes may be observed in a high resolution proton magnetic resonance spectrum when one of the lines is partially saturated by irradiation with a radio frequency field. This is a manifestation of the general Overhauser effect since the intensity changes result from changes in the populations of the eigenstates of the spin hamiltonian. A simple theory is based on the approximation that population changes are negligible for energy-levels not connected by the irradiated transition. This theory appears to be adequate for applications in the analysis of high resolution spectra. Examples are given for systems with weak, intermediate, and strong spin coupling to show how the Overhauser effect may be used to determine the relative signs of spin coupling constants, to locate hidden lines in the spectrum, and to assign spectral lines to transitions between energy-levels. The experimental techniques are discussed. (auth)

**32130** KINETICS OF THE REACTION OF ELEMENTAL FLUORINE WITH ZIRCONIUM CARBIDE AND ZIRCONIUM DIBORIDE AT HIGH TEMPERATURES. A. K. Kuriakose and J. L. Margrave (Univ. of Wisconsin, Madison). 10p. (CONF-14-18)

From American Chemical Society, 144th National Meeting, Los Angeles, Mar.-Apr. 1963.

The fluorination of copper foil was studied at 500°C in order to check the experimental apparatus for fluorination studies. The fluorination of ZrC and $ZrB_2$ was carried out at low $F_2$ partial pressures. The $ZrC-F_2$ reaction was found to be linear with time at a $F_2$ pressure of 31 mm from 278 to 410°C, but breaks above 334°C indicate the breaking up of the fluoride layer on ZrC. The linear rate constants were computed, and the activation energy was found to be 22.1 ± 1.6 kcal/mole. No reaction of $ZrB_2$ with $F_2$ occurred until the temperature reached 500°C and higher; a weight gain was observed at 500°C and 4 mm $F_2$, while weight was lost at 600 to 900°C, with a maximum corrosion rate at 800°C. (D.L.C.)

**32131** THE RELATIONSHIP BETWEEN LATTICE PARAMETERS AND THE COMPOSITION OF STOICHIOMETRIC URANIUM DIOXIDE. D. Jakeš and L. Sedláková (Inst. of Nuclear Physics, Czechoslovak Academy of Sciences, Řež). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/63, 14p. (CONF-120-19). (In Russian)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

A study was made of a product with the composition approximating to $UO_{2.00}$. Specimens were prepared by reduction of ammonium polyuranate in atmospheres of H, a mixture of H and N, and CO at temperatures of 500 to 800°C. The results of a roentgenographic investigation were evaluated from the viewpoint of preparation of the specimen, reduction temperature, and specific surface as determined by the BET method. (auth)

**32132** ON THE FORMATION OF $UC_{1-x}O_x$ AND $UC_{1-x}N_x$. T. Sano, S. Imoto, S. Namba, and M. Katsura (Osaka Univ.). Vienna, International Atomic Energy

Agency, 1963, Preprint CN-16/3, 22p. (CONF-120-2). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

From a thermodynamic study, it was inferred that $UC_{1-x}O_x$ would be in equilibrium with CO gas of $10^{-4}$ mm Hg at 1600°C, if it exists. Compacted mixtures of $UO_2$ and UC or $UC_2$ in several compositions were reacted at 1200, 1600, and 1750°C in vacuo at $10^{-4}$ mm Hg. The main phase after the reaction was identified to be $UC_{1-x}O_x$, where x ranged from 0 to 0.8 according to the initial composition ratio $UO_2$/UC or $UO_2$/$UC_2$. The lattice parameter of $UC_{1-x}O_x$ was found to be changed with heat treatments by a small amount, for example, about 0.2% at x = 0.7, which shows that there is a deviation from stoichiometric composition in $UC_{1-x}O_x$. The heat of formation of $UC_{1-x}O_x$ was measured by DTA using the reaction: $UC_{1-x}O_x + O_2 \rightarrow U_3O_8 + CO_2$. According to the result, the possibility of the existence of uranium monoxide at lower temperatures is increased. The condition of stable existence of $UC_{1-x}N_x$ was also calculated from the free energies of formation of several compounds in the reaction system. The result showed that $UC_{1-x}N_x$, whose x is smaller than a value x' uniquely determined by pressure of $N_2$ and temperature, dissociates into $UC_{1-x'}N_{x'}$ and C or $UO_2$. Whether the latter component is C or $UC_2$ is determined also by the pressure of $N_2$ and the temperature. Experiments on the reaction between $U_2N_3$ and C and between $UC_2$ and $N_2$ were carried out under several different conditions of pressure and temperature. A good accordance was seen between the experimental result and thermodynamic calculation. (auth)

**32133** THE SYNTHESIS OF URANIUM MONOCARBIDE AND DICARBIDE DIRECTLY FROM URANO-URANIC OXIDE. G. H. B. Lovell (Atomic Energy Board, Johannesburg). Vienna, International Atomic Energy Agency, 1963. Preprint CN-16/4, 31p. (CONF-120-3). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

On a commercial scale the use of $UO_2$ for the preparation of uranium carbides may involve difficulties owing to its oxidizing tendency. This possible difficulty was obviated by the use of stable urano-uranic oxide, $U_3O_8$, in place of $UO_2$. Two methods were employed. A mixture of $U_3O_8$ and C is reduced by a gas at temperatures up to 600°C, and the resulting $UO_2$–C mixture caused to react at a higher temperature in an inert atomsphere, or under vacuum to yield the required carbide. A mixture of $U_3O_8$ and C is heated in an inert atmosphere or under vacuum to 600 to 700°C when reduction to $UO_2$ occurs, the resulting $UO_2$–C mixture being caused to react as in the first method. By varying the C contents of the mixtures, satisfactory samples of $UC_2$, UC, and UC + U cermets were prepared. The natures of the reactions are discussed. (P.C.H.)

**32134** NUCLEAR TRANSFER AND ANISOTROPIC MOTIONAL SPIN PHENOMENA: RELAXATION TIME TEMPERATURE DEPENDENCE STUDIES OF WATER ADSORBED ON SILICA GEL. [PART] IV. D. E. Woessner and J. R. Zimmerman (Socony Mobil Oil Co., Inc., Dallas). 53p. (CONF-37-2)

From American Chemical Society Meeting, Dallas, Dec. 1962.

An experimental investigation of the temperature dependence of the nuclear magnetic resonance relaxation phenomena of water vapor adsorbed on silica gel is described. Two-component relaxation data are observed. With temperature increase, the longer $T_2$ value decreases while its fractional population increases. These data are shown to be consistent with nuclear transfers between two state environments possessing distinct relaxation characteristics, and a comparison with theory is made. Evidence of a change of surface characteristics is presented; for early experiments, two-component longitudinal relaxation occurs below a transition temperature; in later experiments, only one-component $T_1$ behavior is found. A theory for an anisotropic motional model for nuclear magnetic dipole-dipole relaxation on surfaces is presented. The motional model is random reorientation of the interproton vector about an axis normal to the surface that occurs much faster than the time dependence of the angle between the vector and this axis. The relaxation processes are thus related to multiple nuclear correlation times. Consequences of an anisotropic model agree with experimental observations. (auth)

**32135** GRAIN GROWTH OF $Ca_{0.16}Zr_{0.84}O_{1.84}$. T. Y. Tien and E. C. Subbarao (Westinghouse Electric Corp., Pittsburgh). 22p. (CONF-50-11)

From American Ceramic Society, 65th Annual Meeting, Pittsburgh, Apr.-May 1963.

Isothermal grain growth of $Ca_{0.16}Zr_{0.84}O_{1.84}$, a cubic solid solution of the fluorite type, was studied between 1600 and 2000°C. The grain size increases as the 0.4 power of time. The growth rate was found to be slower than in metals. The activation energy for grain boundary migration was about 80 kcal/mole. Influence of sintering atmosphere on grain growth is pointed out. (auth)

**32136** THE PRODUCTION OF HEAVY WATER. Jiří Růžička (Inst. of Nuclear Physics, Czechoslovak Academy of Sciences, Prague). p.43-108 of "Technika Hlubokých Teplot." Prague, Publishing House of the Czechoslovak Academy of Sciences, 1961.

Various methods of heavy water production processes on an industrial scale are discussed. The principles, theory, and technology processing for the water distillation method, water electrolysis, and methods of chemical exchange reactions are explained. Special attention is given to the hydrogen distillation method at low temperatures, and to the technological problems connected with the method, such as problems of the most convenient and effective distillation column design, refinement of the raw hydrogen entering the distillation plant, material and design problems of expanders, and thermal insulation problems of large scale low temperature device. Operational and investment costs necessary to produce a unit of quantity of heavy water are given for various methods. From the values the efficiency and advantages of various methods and devices are compared with the result that most efficient and advantageous method for heavy water large scale production for nuclear engineering purposes is the low temperature hydrogen distillation method. (auth)

**32137** RECENT DEVELOPMENTS IN THE CHEMISTRY OF RHENIUM AND TECHNETIUM. J. E. Fergusson, W. Kirkham, and R. S. Nyholm. p.36-44 of "Rhenium." New York, American Elsevier Publishing Co., Inc., 1962.

The chemistry of the oxidation states of Re and Tc is considered with respect to electron configuration, stereochemistry, and magnetic properties. Brief mention is made of relations to Mn. A review of the use of the ligand, o-phenylene-bisdimethylarsine, which has facilitated the preparation of a series of Re and Tc complexes and has enabled the characterization of certain lower oxidation states that were previously poorly defined, is also given. • (Rev. Metal Lit., 20: No. 1, Jan. 1962)

**32138** ISOTOPE EXCHANGE BETWEEN $H_2S$ AND SULFIDES. M. Lederhausen. Thesis, Bonn, Universität, 1962. 96p. $2.00.

Isotope exchange between gaseous $H_2S$ and sulfide crystals was investigated using $S^{35}$. The activity in the gas phase was measured with a special counter tube using a molybdenum wire as anode. The isotope exchange between the liquid and gas phase was studied for CdS, PbS, and FeS. For simple crystals of CdS no isotope exchange could be detected. For powdered CdS an exchange was observed for temperatures between 200 and 500°C. Experiments with PbS gave similar results. With single crystals of FeS an exchange was detected between 200 and 500°C. This can be explained by a sulfur uptake of the lattice. (Gmelin Inst.)

**32139** POLAROGRAPHIC STUDIES OF PLUTONIUM IN AQUEOUS SOLUTION. D. Nebel. Dresden, Technische Hochschule, 1961. 150p. $2.00.

The construction of a plutonium laboratory with eight glove boxes is described. Pu with different valencies (Pu(III), Pu(IV), Pu(VI)) was produced by controlled-potential electrolysis. The polarographic properties of Pu(IV) in acetate solution are studied in detail. The reduction point to Pu(III) for −0.2 v is irreversible. This step is proportional to the concentration between $10^{-3}$ and $10^{-5}$ moles Pu(IV). In an acid medium ($HClO_4$) a step was observed for −1 v. Pu(IV) and acetate form a complex compound. This property makes possible the ion-exchange separation of Pu and Ce. The standard and redox potentials of Pu are given. (Gmelin Inst.)

## Organic Chemistry

**32140** PURIFICATION OF RADIOACTIVE ORGANIC COMPOUNDS: A NONCONTAMINATING GAS LIQUID CHROMATOGRAPHIC SYSTEM. Marvin L. Whisman and Barton H. Eccleston (Petroleum Research Center, Bartlesville, Okla.). Anal. Chem., 35: 1333-4(Aug. 1963).

Decontamination of a gas liquid chromatography (GLC) unit by substituting a flame ionization detector for the usual thermal conductivity detector, and using a modified injector, stream splitter, and outlet block is described. The system allows purification of 2 or 3 labeled materials in an 8-hr period using a single GLC unit. (P.C.H.)

**32141** SYNTHESIS OF L-ARABINOSE-5-$C^{14}$. R. K. Hulyalkar and J. K. N. Jones (Queen's Univ., Kingston, Ont.). Can. J. Chem., 41: 1898-1904(Aug. 1963).

L-Arabinose-5-$C^{14}$ was synthesized by the following route: D-xylose → D-gulono-1,4-lactone-1-$C^{14}$ → 2,3 : 5,6-di-O-isopropylidene-D-gulono-1,4-lactone-1-$C^{14}$ → 2,3-O-isopropylidene-D-gulono-1,4-lactone-1-$C^{14}$ → 3,4-O-isopropylidene-2,5-L-arabino-urono-lactone-5-$C^{14}$ → methyl-α,β-L-arabinofuranosido-methyl uronate-5-$C^{14}$ → methyl-α,β-L-arabinofuranoside-5-$C^{14}$ → L-arabinopyranose-5-$C^{14}$. The overall radiochemical yield of L-arabinose-5-$C^{14}$ was about 14% based on $KC^{14}N$ used in the first step. The structures of the isopropylidene derivatives of D-gulono-lactone were clarified. (auth)

**32142** TRITIATION OF AROMATICS BY HTO-PROMOTED ALUMINUM CHLORIDE. Constanta Măntescu and Alexandru T. Balaban (Inst. of Atomic Physics, Bucharest). Can. J. Chem., 41: 2120-1(Aug. 1963).

The effects of tritiated water on derivatives of benzene and pyridine in the presence of aluminum chloride were investigated. The specific activities obtained reflect the order of decreasing reactivity towards electrophilic substitution: benzene ~ fluorobenzene > chlorobenzene > 2,4,6-collidine > 2,6-lutidine > pyridine > nitrobenzene. (P.C.H.)

**32143** PROBLEMS OF TRITIATION: PREPARATION OF TRITIATED S-(1,2-DICHLOROVINYL)-L-CYSTEINE. P. Klubes and M. O. Schultze (Univ. of Minnesota, St. Paul). Intern. J. Appl. Radiation Isotopes, 14: 241-4(July 1963). (In English)

An attempt to prepare pure tritiated S-(1,2-dichlorovinyl)-L-cysteine (DCVC) by exposing an authentic specimen of this compound to tritium gas by the Wilzbach procedure failed. From the product formed, DCVC was isolated which had the correct physicochemical properties but low, if any, radioactivity; it contained radioactive impurities from which it could not be separated by the methods used. Tritiation of pure L-cystine by the same procedure afforded a specimen which, after extensive purification, contained most of the radioactivity in the form of L-cystine, and two minor radioactive contaminants. After reduction with sodium in liquid ammonia, treatment with trichloroethylene, and purification, it afforded tritiated DCVC with a specific activity of 4.92 μc/mmole. During this synthesis about two thirds of the radioactivity were lost, presumably through exchange in liquid ammonia. (auth)

**32144** ZIRCONIUM CYCLOPENTADIENYL COMPOUNDS CONTAINING ACYLOXY GROUPS. E. M. Brainina and R. Kh. Freidlina (Inst. of Elementary Organic Compounds, Academy of Sciences, USSR). Izv. Akad. Nauk SSSR, Otd. Khim. Nauk, No. 5, 835-8(May 1963). (In Russian)

A synthesis of zirconium triacyloxycyclopentadienyl compounds was produced by reaction of carboxylic acids (acetic, valeric and enanthic) with zirconium dicyclopentadienyl dichloride. Exchange reaction of zirconium cyclopentadienyl triacetate with benzoic acid formed zirconium cyclopentadienyl tribenzoate. A zirconium dicyclopentadienyl bis-trifluoroacetate was produced by reaction of trifluoroacetic acid with zirconium dicyclopentadienyl dichloride, and zirconium cyclopentadienyl acetate with acetylacetonate was formed by reaction of acetylacetone with zirconium cyclopentadienyl triacetate. (R.V.J.)

**32145** VIBRATIONAL ASSIGNMENT OF ISOXAZOLE-$d_3$. G. Adembri (Università, Florence), G. Speroni, and S. Califano. Spectrochim. Acta, 19: 1145-52(July 1963).

The vapor and liquid phase spectra of isoxazole-$d_3$ were measured over the range 4000 to 400 $cm^{-1}$. Isoxazole-$d_3$ was prepared by reaction between $C_2D_2$ and DCNO under a pressure of 2 atm of $C_2D_2$, using $D_2O$ as solvent. Comparison with the spectra of the light isotope, previously studied, leads to a complete vibrational assignment, which fits the product rule within 2%. (auth)

**32146** NORMAL VIBRATIONS OF GLYCINE AND DEUTERATED GLYCINE MOLECULES. Shigeko Suzuki, Takehiko Shimanouchi, and Masamichi Tsuboi (Tokyo Univ.). Spectrochim. Acta, 19: 1195-1208(July 1963).

Infrared absorption spectra of the α-form crystals of glycine ($NH_3^+CH_2COO^-$), glycine-$d_3$ ($ND_3^+CH_2COO^-$), glycine-$d_2$ ($NH_3^+CD_2COO^-$), and glycine-$d_5$ ($ND_3^+CD_2COO^-$) were observed in the spectral region of 4000 to 280 $cm^{-1}$. A normal coordinate treatment was made of each of these four molecules as a seven-body system. Based upon the results of these observations and treatment, discussions are given on the normal vibrations of glycine molecules. (auth)

**32147** REACTIONS OF SCANDIUM CHLORIDES WITH ETHYLENEDIAMINE. B. N. Ivanov-Emin, L. A. Nisel'son,

and T. D. Sokolova. Zh. Neorgan. Khim., 8: 1381-3(June 1963). (In Russian)

Exothermic reactions of $ScCl_3$ with ethylenediamine at 20°C result in variable compounds. At 120° $ScCl_3$ reaction with ethylenediamine forms $ScCl_3 \cdot 2$ eu compound that releases most of the ethylenediamine at 214 to 219°C. At further rise of temperature the inorganic part of the complex decomposes discharging part of chloride as ethylenediamine chloride. In ethylenediamine–ether solutions $ScCl_3$ forms a compound close to $ScCl_3 \cdot 5$ eu. (R.V.J.)

**32148** SOLUBILITY OF RARE EARTH DIALKYL PHOSPHATES AS FUNCTION OF DIALKYL-PHOSPHORIC ACID CONCENTRATION IN BENZENE. E. E. Kriss. Zh. Neorgan. Khim., 8: 1505-11(June 1963). (In Russian)

An analysis was made of neodymium and ytterbium($MA_3$) di-n-octyl and di-n-butyl phosphate solubility in various concentrations of dialkyl-phosphoric acids (HA) in benzene. An increased $MA_3$ solubility was observed with increased concentrations of dialkyl phosphoric acid. The obtained data were used for calculating equilibrium constants of $MA_3 \cdot 3HA$ complex formation. (R.V.J.)

**32149** SOLUBILITY OF NEODYMIUM DI-N-BUTYL PHOSPHATE IN DI-N-BUTYL PHOSPHORIC ACID WITH VARIOUS DILUENTS. E. E. Kriss. Zh. Neorgan. Khim., 8: 1512-15(June 1963). (In Russian)

Neodymium dibutyl phosphate solubility in dibutyl phosphoric acid as a function of various diluents is reduced according to the following order: carbon tetrachloride > n-hexane > iso, octane > benzene, diethyl ether > formic acid > dichloroethane > n-octyl alcohol > n-butyl alcohol > n-propyl alcohol > pyridine, ethyl alcohol. The competition between neodymium dibutyl phosphate and diluent in capturing dibutyl phosphate molecules determines concentration equilibrium of the dissolved compound. (R.V.J.)

**32150** STUDIES OF THE SYNTHESIS OF $C^{14}$ LABELED ORGANIC COMPOUNDS USING A VACUUM APPARATUS. L. Schmidt. Thesis, Dresden, Universität, 1962. 100p. $2.00.

A special method for synthesis using $BaC^{14}O_3$ was developed. Measurements of $C^{14}$ activities with a liquid scintillation counter are described. Methods for the synthesis of various organic compounds are given. Specific activities up to 20 mc/m mole can be obtained. (Gmelin Inst.)

**32151** ISOTOPE EXCHANGE OF DEUTERIOSULFURIC ACID WITH PIVALIC ACID. Gus A. Ropp (Union Carbide Consumer Products Co., Parma, Ohio). 6p. (CONF-14-17)

From American Chemical Society, 144th National Meeting, Los Angeles, Mar.-Apr. 1963.

A synthesis of methyl-deuterated $(CH_3)_3CCOOH$ was attempted by exchange with excess $D_2SO_4$ at 45 to 55°C for 40 hr. Analysis of the product indicated ≥90% replacement of the methyl group hydrogen atoms by deuterium atoms. The ionization-constant ratio $K_a(H)/K_a(D)$ was determined to be 1.063 for $(CH_3)_3CCOOH$ and $(CD_3)_3CCOOH$ and 1.02 ± 0.01 for $CH_3COOH$ and $CD_3COOH$. The lowering of the ionization constant per deuterium atom is 0.7% for pivalic acid, 2% for acetic acid, and 6% for formic acid. This is consistent with an inductive mechanism for the effect of substituted deuterium on the ionization constant of a carboxylic acid. (D.L.C.)

## Radiation Chemistry and Radiochemistry

*Refer also to abstracts 31796, 31807, 31808, and 31809.*

**32152** (CONF-14-21) TRITIUM β-DECAY INDUCED REACTIONS IN THE POLYSTYRENE FLUFF. John Y. Yang and Ronald B. Ingalls (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). [1963]. Contract [AT(11-1)-Gen-8]. 17p.

From the American Chemical Society Meeting, Los Angeles, Calif., March–April 1963.

The Wilzbach gas-exposure method for tritium labeling of organic compounds was studied with finely divided polystyrene fluff as the reaction substrate. Such a technique permits the direct observation of radical intermediates during the course of reaction by means of electron spin resonance. The observed tritium labeling efficiency in the tritium-fluff system compared favorably with those reported for vapor phase labeling of structurally similar hydrocarbons, and it was further enhanced by the presence of xenon. Isotopic distribution of tritium labeling was found predominantly in the aromatic positions of the polystyrene molecule. Absorption of β energy in the fluff was found to result primarily in cross-linking of the polymer. The importance of intermediates arising from the interaction of β radiation with gaseous reactants is suggested for tritium incorporation. (auth)

**32153** (JEN-119-DF/I-36) ANALISIS DE LOS PROCESOS NUCLEARES PRODUCIDOS AL BOMBARDEAR GAS ACETILENO CON UN HAZ DE PARTICULAS $^3He$ DE 29 Mev. (Nuclear Processes Produced by Bombardment of CH ≡ CH Gas Target with a 29 Mev $He^3$ Particle Beam). Gerardo Pardo Sanchez (Spain. Junta de Energia Nuclear, Madrid). 1963. 16p.

The interactions of a CH ≡ CH target with a 29-Mev $He^3$ particles beam were analyzed. The results for elastic and inelastic processes $C^{12}(He^3, He^3)C^{12}$, $C^{12}(He^3, He^3)C^{*12}$, $C^{12}(He^3, \alpha)C^{11}$, $C^{12}(He^3, d)N^{13}$, and $H^1(He^3, He^3)H^1$ are presented. For the interaction radius, a value of 5.35 ± 0.24 fermis was obtained by the black disk formula. The observed angular distributions were compared, when possible, with the predictions of Blair and A.B.M. direct interaction theories. The angular distributions for the elastic scattering of $He^3$ by $H^1$ was checked with theoretical predictions based on the resonating group theory. (auth)

**32154** (NAS-NS-3108) APPLICATION OF DISTILLATION TECHNIQUES TO RADIOCHEMICAL SEPARATIONS. James R. DeVoe (National Bureau of Standards, Washington, D. C.). Aug. 1962. 44p.

"Nuclear Science Series" of the National Research Council. Committee on Nuclear Science.

The use of vacuum distillation of inorganic compounds and metals for radiochemical separations is reviewed. A brief description of the experimental apparatus which is most often used for the distillation is outlined. Advantages and disadvantages of the various techniques are discussed. Detailed separation procedures are described for wet chemical distillation separations as well as for separations of daughter radioactivity from target materials by direct heating of the target. (auth)

**32155** (TID-19203) THE KINETICS OF THE GAMMA RADIOLYSIS OF CHLOROFORM (thesis). Horst Robert Werner (Western Reserve Univ., Cleveland). Sept. 1963. Contract [AT(11-1)-685]. 206p.

A review of advances in radiation chemistry is presented as a background to the study of the radiolysis of chloroform. Reagents, sample preparation, irradiation procedure, analyses for radiolysis products, and dosimetry are discussed. A total of 47 samples were irradiated and analyzed. Compounds formed in the radiolysis of chloroform include: methylene chloride, carbon tetrachloride, sym-

metrical tetrachloroethane, pentachloroethane, hexachloroethane, tetrachloroethylene, hexachloropropane, octachloropropane, other organic compounds in trace amounts, HCl, $Cl_2$, $H_2$, and some products containing atoms foreign to chloroform. Radical scavengers (halogens) were used, and their products are also discussed. Reaction mechanisms for producing the products observed were studied. (M.C.G.)

**32156** THE THERMAL AND RADIATION STABILITY OF A NUMBER OF AROMATIC COMPOUNDS. Yu. G. Sevast'yanov, L. A. Bulanov, A. P. Smirnov-Averin, E. P. Kaplan, O. M. Nefedov, M. A. Chel'tsova, and A. D. Petrov. At. Energ. (USSR), 14: 555-8(June 1963). (In Russian)

A number of organic compounds were tested for thermal stability by heating at 400°C in a graphite block in sealed quartz ampoules. The amount of gas formation (mostly hydrogen), and the % residual polymer were taken as indications of the thermal stability. Diphenyl and the isomers of terphenyl were found to have the highest thermal stability. The thermal stability of the tri-isopropyl derivative of m-terphenyl was much lower than the thermal stability of the monoisopropyl derivative. The presence of a methylene bridge between the phenyl groups resulted in a decrease in thermal stability by a factor of 1000 as compared to the stability of m-terphenyl. Diphenyl and the terphenyls showed the greatest radiation stability on being subjected to a $\gamma$ dose of $1 \times 10^{21}$ ev/g or to a neutron dose of $1 \times 10^{23}$ ev/g at 60 and 350°C. The results indicated that the pyrolysis of m-terphenyl leads to the formation of the dimer of m-terphenyl and the evolution of hydrogen gas. (TTT)

**32157** THE RELATION TO THE BEHAVIOR OF A BORON COMPOUND IRRADIATED WITH NEUTRONS TO FEATURES OF THE CRYSTAL STRUCTURE. G. V. Samsonov. At. Energ. (USSR), 14: 588-90(June 1963). (In Russian)

The burnout of $B^{10}$ leads to swelling, and to the evolution of helium at high temperatures with deformation and cracking of the irradiated boron material. The crystalline compounds which are the most sensitive to the effects of neutron irradiation such as boron, boron carbide, and the tetra- and hexaborides contain a three-dimensional lattice of boron atoms, while the diborides, which are the most stable to neutron irradiation, contain hexagonal layers of metal atoms alternating with layers of boron atoms which form a hexagonal two-dimensional network. Helium can escape from a shell-type lattice only by disrupting the lattice. In the case of the layer-lattice type of structure as in the diborides, helium can escape from the lattice with a minimum amount of damage to the lattice. A $MeB_2$ compound allows the relatively free escape of helium, and yet, the lattice has a reinforcing effect so that this type of compound is the most suitable from the point of view of stability to neutron irradiation. Covalent binding decreases the stability of a boron compound. It is predicted that BN, which has the structure of graphite, should be stable to neutron irradiation. Also, the diborides of niobium, tantalum, and chromium should be relatively stable to neutron irradiation. (TTT)

**32158** THE $Co^{60}$ $\gamma$-RADIOLYSIS OF AQUEOUS CYSTINE SOLUTIONS. I. THE EFFECT OF CHLORIDE ION ON THE AMMONIA YIELD. W. A. Armstrong and D. W. Grant (Defence Research Chemical Labs., Ottawa). Can. J. Chem., 41: 1882-7(Aug. 1963). (DRCL-407)

Sodium chloride was found to increase the ammonia yield from $Co^{60}$ $\gamma$-irradiated cystine in 0.02 M $H_2SO_4$. The effect is attributed to the participation of chlorine atoms, which deaminate the amino acid to a greater extent than hydroxyl radicals. The ratio of the rate constants $k_{OH + cystine}/k_{OH + Cl^-}$ was determined to be 24 in 0.02 M $H_2SO_4$. (auth)

**32159** ULTRAVIOLET IRRADIATION OF PYRIMIDINE DERIVATIVES. IV. ANIONIC EFFECTS ON THE PHOTOLYSIS OF CYSTOSINE AND O-METHYLCYTOSINE. A. M. Moore (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Chem., 41: 1937-50(Aug. 1963).

The course of the photochemical reactions involved in the photolysis of O-methylcytosine is strongly affected by the presence of various anions. Similar anionic effects were noted during the photolysis of cytosine, but the products of the reaction appeared to be less suitable for further investigation. Ultraviolet irradiation of O-methylcytosine in water leads to destruction of the characteristic absorption bands, while irradiation in phosphate leads to the production of a new compound with marked absorption at 300 m$\mu$, and irradiation in pyrophosphate, glycerophosphate, citrate, or cacodylate leads to the production of compounds with marked absorption at 274 m$\mu$. The phosphate-dependent photolysis of O-methylcytosine was studied in some detail and the product was isolated and purified. Apparently the $H_2PO_4^-$ ion acts as a catalyst in a reaction which involves the loss of 1 mole of ammonia and the addition of 2 moles of $H_2O$ to O-methylcytosine. (auth)

**32160** IONIZATION AND DISSOCIATION OF FORMATE ESTERS BY ELECTRON IMPACT. D. Van Raalte and A. G. Harrison (Univ. of Toronto). Can. J. Chem., 41: 2054-9(Aug. 1963).

The mass spectra of methyl formate-d, ethyl formate-d, and isopropyl formate-d were compared with the mass spectra of the undeuterated compounds. By use of the deuterium labeling and appearance potential studies the dissociation reactions leading to a number of the oxygen-containing ions were elucidated. The proton affinity of formic acid was estimated to be 157 kcal/mole from the appearance potential of the $HC(OH)_2^+$ ion in the mass spectra of ethyl formate and isopropyl formate. (auth)

**32161** A CONTRIBUTION TO THE COURSE OF LUMINESCENCE OF PURE AND DOPED AgCl CRYSTALS. K. Vacek (Charles Univ., Prague). Czech. J. Phys., 13: 424-30(1963). (In English)

Some new measurements of the luminescence of pure and doped AgCl crystals are dealt with and evaluated, in particular the shift of the blue-green emission band as a function of the doped ion and the temperature shift of this band. The concentration of luminescence center in pure AgCl crystals and the creation of x-ray luminescence in AgCl crystals at room temperature are briefly discussed. (auth)

**32162** STUDIES IN THE RADIOLYSIS OF FERROUS SULFATE SOLUTIONS. I. THE EFFECT OF OXYGEN CONCENTRATION IN 0.8 N SULFURIC ACID. Satoru Tsuda and Yasuo Kikuchi (Hiroshima Univ.). Doitai To Hoshasen, 4: 206-13(Sept. 1962).

Data obtained on the effects of $O_2$ concentration changes in $H_2SO_4$ by means of a direct analytical method for $O_2$ are given and interpreted in terms of free radical theory. Detailed experimental procedure and results are given. Samples of $H_2SO_4$ (0.8N) and ferrous ammonium sulfate ($5 \times 10^{-3}$ M) were placed in tubes (pre-irradiated to the order of $10^8$ r) of 14 mm in dia and 15 cm long. In order to prevent air contact with the sample, a layer of liquid paraffin (about 0.5 cc) was used to cover the sample surface. The tubes were then irradiated with a 120-C $Co^{60}$ $\gamma$ source at $6.5 \times 10^4$ r/hr at 20°C up to $2 \times 10^5$ r. The proposed direct

analytical or modified Shibata-Miller method was used to determine the $Fe^{3+}$ yield from $Fe^{2+}$ by spectrophotometric reading at 304 mμ. The amount of $O_2$ was then calculated from the $Fe^{3+}$ yield. The γ induced oxidation rates of $Fe^{2+}$ in 0.8N $H_2SO_4$ could be determined as a function of the $O_2$ concentration. The equation, $G(Fe^{III}) = 8.18 + 7.4/[1 + K(Fe^{2+})/(O_2)]$, was confirmed. However, K = 1.4/1000 instead of 1/1200 was used. (OID)

**32163** STUDIES IN THE RADIOLYSIS OF FERROUS SULFATE SOLUTIONS. II. THE EFFECT OF OXYGEN CONCENTRATION IN 0.05 N SULFURIC ACID. Satoru Tsuda and Yasuo Kikuchi (Hiroshima Univ.). Doitai To Hoshasen, 4: 214-20(Sept. 1962).

Experiments were carried out on the radiolysis of ferrous sulfate in 0.05 N $H_2SO_4$ solutions. In the case of a small dosage of $46.3 \times 10^{16}$ ev/g $H_2O$, or 7 min of irradiation, the equation

$$G(Fe^{III}) = 4.4 + \frac{3.5}{1 + \frac{5.5\,[Fe^{2+}]}{1000\,[O_2]}}\left\{2.84 + \frac{5.5\,[Fe^{2+}]}{1000\,[O_2]}\right\}$$

was obtained; but in the case of a 30-min irradiation,

$$G(Fe^{III}) = 4.4 + \frac{3.5}{1 + \frac{5.5\,[Fe^{2+}]}{1000\,[O_2]}}\left\{2.60 + \frac{5.5\,[Fe^{2+}]}{1000\,[O_2]}\right\}$$

was found. (TCO)

**32164** SEPARATION OF SCANDIUM-49 FROM A CALCIUM TARGET. A. H. Soloway, J. F. Balcius, and R. G. Ojemann (Massachusetts General Hospital, Boston). Intern. J. Appl. Radiation Isotopes, 14: 245-9(July 1963). (In English)

A method is described for the rapid separation of $Sc^{49}$ from a calcium target, following neutron irradiation. Disruption of the crystal structure of the calcium salt and precipitation of an insoluble calcium derivative permitted the recovery of 80 per cent of the $Sc^{49}$. This is compared with a 20 per cent recovery by leaching of an insoluble calcium salt. From irradiation studies, $Na^{24}$ is produced as a contaminant in analytical reagent calcium carbonate. For the preparation of curie amounts of $Sc^{49}$ for use in tumor therapy, hundreds of millicuries of $Na^{24}$ would be formed. Such levels would be unsatisfactory. (auth)

**32165** THE RADIOLYSIS AND PYROLYSIS OF ORGANIC COOLANTS. A. W. Boyd (Atomic Energy of Canada Ltd., Chalk River, Ont.). J. Nucl. Mater., 9: 1-17(June 1963). (In English)

The results of pyrolytic and radiolytic studies of biphenyl and the terphenyls are reviewed. Pyrolytic rate constants and activation energies obtained are listed and the effect of additives and the reaction order and proposed mechanisms in pyrolysis are discussed. There is general agreement that the formation of compounds of higher molecular weight, which are the major products in pyrolysis, is a first order process but there is considerable variation in the values of the rate constants obtained. The review of the radiolytic work includes discussions of the nature and yields of the products and the effects of dose rate, additives, type of ionizing radiation, and temperature upon the yields as well as the mechanisms proposed. Evidence is given to show that the stability of the polyphenyls to radiation decreases both with increasing track density of the ionizing radiation and with temperature. Other organic coolants are considered briefly. (auth)

**32166** ELECTRON MAGNETIC RESONANCE IN γ-IRRADIATED SINGLE CRYSTALS OF SODIUM THIOSULFATE—EFFECT OF DEHYDRATION. Roger Servant and Joeel Rocher (Faculté des Sciences, Bordeaux). J. Phys., 24: 285-6(Apr. 1963). (In French)

The electron magnetic resonance of $Na_2S_2O_3$ is measured at 10 Gc, as a function of the angle between the direction of observation and the direction of the binary axis of the crystal. Peaks are observed corresponding to free-electron oscillations and to a strong spin-orbit interaction of dislocated electrons. This latter type of peak is assumed to be caused by the presence of $\cdot SO_3Na_2$. The peaks are identical for samples prepared by dehydration of $Na_2S_2O_3 \cdot 5H_2O$, followed by irradiation. (T.F.H.)

**32167** USE OF DIMALEIMIDES AS ACCELERATORS FOR THE RADIATION-INDUCED VULCANIZATION OF HYDROCARBON POLYMERS. PART II. SYNTHETIC RUBBERS AND SATURATED POLYMERS. S. M. Miller, M. W. Spindler, and R. L. Vale (Atomic Energy Research Establishment, Wantage, Berks, Eng.). J. Polymer Sci., Pt. A, 1: 2537-49(Aug. 1963).

The effect of m-phenylenedimaleimide on the rate of cross-linking of synthetic rubbers, polyvinyl acetate, polyvinyl chloride, polyethylene, and other polymers, under the action of ionizing radiation is described. The dose reduction factor for equivalent degrees of cross-linking obtained with and without the maleimide varies from 10 to 25 for the synthetic rubber. Further evidence is given to show that maleimides sensitize the vulcanization of unsaturated polymers, principally by copolymerization, and certain saturated polymers containing labile atoms, by a transfer mechanism. (auth)

**32168** SZILARD-CHALMERS EFFECT IN SOME COMPLEX COMPOUNDS. 1. APPLICATION OF POTASSIUM NITROSYLOPENTACYANOMANGANATE AS TARGET. J. Mikulski, T. Senkowski, and T. Stroński (Inst. for Nuclear Physics, Chemistry and Radiochemistry Lab., Kraków and Jagiellonian Univ., Kraków). Kernenergie, 6: 294-5(June 1963). (In German)

The Szilard-Chalmers reaction in potassium nitrosylopentacyanomanganate to produce $Mn^{56}$ was investigated. The retention coefficient and enrichment coefficient were determined. The target was irradiated with thermal neutrons from a Po–Be source. (M.C.G.)

**32169** DECOMPOSITION OF ALKALI METAL NITRATES BY LIGHT IONS OF KILOVOLT ENERGY. S. R. Logan (Univ. of Leeds, Eng.). Nature, 199: 369-70(July 27, 1963).

An alternative interpretation of the reaction processes for the cation bombardment of alkali metal nitrates in the energy range of 1 to 15 kev that is qualitatively consistent with the experimental results and revised assessments of the displacements produced by atomic collisions are presented. (P.C.H.)

**32170** RADIATION CHEMISTRY OF HYDROCARBONS. Ffrancon Williams (Univ. of Tennessee, Knoxville). Quart. Rev. (London), 17: 101-32(1963).

A review of the radioinduced reactions of hydrocarbons is presented in which the quantitative theory of molecule-ion reactions is outlined. Emphasis is placed on the rates and energetics of the unimolecular and bimolecular processes which lead to the formation of molecules, uncharged free radicals, and secondary ions. The review is divided into sections dealing with the historical development, energy absorption from ionizing radiation, elementary reactions, and macroscopic radiation chemistry. In the last two sections, polyatomic ions, ion-molecule reactions, electronic excitation processes, and reactions in the gas, liquid, and polymeric solid phases are considered. (D.L.C.)

**32171** MECHANISM OF THE CHANGE IN RATE OF ELECTRODIC REACTIONS UNDER THE ACTION OF ELECTRONIC IRRADIATION. V. D. Val'kov and A. V. Byalobzheskii (Inst. of Physical Chemistry, Academy of Sciences, USSR). Zh. Fiz. Khim., 37: 1205-12(June 1963). (In Russian)

It is shown that ionizing radiation causes two types of effects. Radiation-electrochemical, when the change in rate of the electrode reaction is due to the apperance of new substances, radiolysis products of the corrosion medium, in the solution, and photoelectrochemical, when the change in the course of the electrode reaction is associated with the photosensitvity of the oxide film on the electrode surface. The principal part is played by the radiation-electrochemical effect, which occurs both in cathodic and anodic polarization of the metals. The formation or growth in thickness of oxide layers considerably lowers this effect. The semiconductor nature of the layers affects the electrochemical behavior of the metals in the radiation process. For electrodes with n-type films the photoelectrochemical effect appears only on anodic polarization and with films of the p-type, only on cathodic polarization. The effect increases with the thickness of the oxide films. (auth)

**32172** ON PREPARATION AND PROPERTIES OF SCANDIUM NITRATES. L. N. Komissarova, G. Ya, Pushkina, and V. Spitsyn (Moscow State Univ.). Zh. Neorgan. Khim., 8: 1384-94(June 1963). (In Russian)

Crystalline normal nitrates and scandium oxynitrates were synthesized into the following compounds: $Sc(NO_3)_3 \cdot 4H_2O$, $Sc(NO_3)_3 \cdot 2H_2O$, $ScOH(NO_3)_2 \cdot 3H_2O$, $Sc_4O_3(NO_3)_6 \cdot 6.5\ H_2O$, and $Sc_4O_5(NO_3)_2$. It was established that $Sc(NO_3)_3 \cdot 4H_2O$ and $ScOH(NO_3)_2 \cdot 3H_2O$ are crystallized in solutions with $Sc_2O_3 : N_2O_5$ ratio 1:3 and 1:2, respectively. A dehydrate $Sc(NO_3)_3 \cdot 2H_2O$ was formed by dehydration of a tetrahydrate while oxynitrates $Sc_4O_3(NO_3)_6 \cdot 6.5\ H_2O$ and $Sc_4O_5(NO_3)_2$ formed by thermal decomposition of nitrate hydrates. Studies were made of density, solubility refractive indices and optical characteristics of synthesized compounds and it was found that they are thermally unstable. The thermal analysis of $Sc(NO_3)_3 \cdot 4H_2O$ and $ScOH(NO_3)_2 \cdot 3H_2O$ indicated lack of coordinate scandium saturation. (R.V.J.)

**32173** STUDIES OF THE SEPARATION OF SHORT-LIVED NUCLIDES BY $\beta$ RECOIL. H. Mundschenk. Thesis, Mainz, Universität, 1962. 125p. $2.00.

The construction of a continuous separation system using the recoil effect is described. Separation and identification of nuclides with half lives between 1 and 500 sec are possible. The aging process of various emitter metals is discussed. (Gmelin Inst.)

**32174** IZOTOPY. ISTOCHNIKI IZLUCHENII I RADIOAKTIVNYE MATERIALY. KATALOG. IZDANIE VTOROE, DOPOLNENNOE. (Isotopes. Sources of Emissions and Radioactive Materials. Catalog. Expanded Second Edition). Moscow, Gosatomizdat, 1962. 220p.

Extensive data are included on preparation, properties, and applications of radioactive and stable isotopes. Tables are given of the basic characteristics of isotopes and labelled compounds. (R.V.J.)

**32175** VAPOR PHASE NITRATION OF PROPANE: EFFECT OF GAMMA RADIATION AND TEMPERATURE. Roberto Lee, Tae Chung, and Lyle F. Albright (Purdue Univ., Lafayette, Ind.). 18p. (CONF-14-2)

From American Chemical Society Meeting, Los Angeles, Mar.-Apr. 1963.

Propane was nitrated with nitric acid in a flow reactor that was subjected to 195,000 r/hr of gamma radiation. Operating variables investigated included temperatures from 370–460°C, mole ratios of propane to nitric acid from 4:1 to 16:1, and residence times of 1.1 to 1.9 sec. Irradiation of the reacting mixture had little effect on the nitric acid conversions except when oxygen was added to the reactants; an approximately 10-15% relative increase in conversion was noted. A similar increase was noted when liquid propane was irradiated prior to reaction. The effect of temperature on the distribution of nitroparaffin products was evaluated for several series of irradiated and unirradiated runs. (auth)

**32176** RADIATION CHEMISTRY OF POLYMERS. Adolphe Chapiro (CNRS, Bellevue, France). 19p. (CONF-81-2)

From Conference on Basic Mechanisms in the Radiation Chemistry of Aqueous Media, Gatlinburg, Tenn., May 1963.

A review is presented of the radiation chemistry of solid polymers and of polymers in solution. Tables are presented of the average G-values of chemical changes in polyethylene and of crosslinking and degradation in various polymers. Hot-radical and ion-molecule reaction mechanisms are discussed. Radiolysis of polymethyl methacrylate and polystyrene in solution is discussed, and specific effects in water are considered. (D.L.C.)

**32177** RADIATION INITIATED COPOLYMERIZATION OF STYRENE WITH UNSATURATED ESTERS. W. Burlant and J. Hinsch (Ford Motor Co., Dearborn, Mich.). 27p. (CONF-121-1)

From International Symposium on Radiation Induced Polymerization and Graft Copolymerization, Columbus, Ohio, Nov. 1962.

The kinetics of the $\gamma$-initiated, gel-forming copolymerization of styrene with unsaturated esters containing 1.5 double bonds per molecule of average molecular weight of 890 (derived from maleic anhydride, phthalic anhydride, and propylene glycol) were studied with initial ester concentrations ranging from 65 to 2.4%. From experimentally determined gel fractions, rates of disappearance of styrene and ester unsaturation (measured up to complete conversion of ester unsaturation), and the degree of polymerization of the growing chains, a model is suggested based on a free radical copolymerization, assuming a single effective propagation and termination rate constant ($k_p$ and $k_t$, respectively), and bimolecular chain termination except between a pair of immobile gel radicals. Three ester concentration ranges were considered. At high ester concentrations (≥50%), styrene and ester enter the gel at a constant rate (molar ratio of styrene : ester double bond of 2:1), precluding application of conventional copolymer composition theory. The rate at which styrene is consumed in the dilute ester-styrene solutions (≤4.6%), where $M_2^0$ (initial molar concentration of ester unsaturation) is negligibly small, is given by $d\alpha_1/dt = k_p (k_1/2k_t)^{1/2}$. Polymerization rates of the intermediate ester concentration ranges (10 to 30%) were higher than predicted from the simple model. An empirical rate expression is presented that describes the systems to 40% conversion of styrene. (P.C.H.)

**32178** CATALYSIS BY IRRADIATION IN PRESENCE OF NONMETALLIC SOLIDS. R. Coekelbergs, A. Crucq, J. Decot, L. Degols, A. Frennet, G. Lienard, and L. Timmerman (Universitè, Brussels). 25p. (CONF-81-1). (In French)

From Conference on Basic Mechanisms in the Radiation Chemistry of Aqueous Media, Gatlinburg, Tenn., May 1963.

A discussion is presented of the catalytic effects of irradiation in the presence of nonmetallic solids. Only the effects connected with the modification of the stationary concentrations of charge-carriers are considered. The influence of this modification on the kinetics and equilibria of heterogeneous reactions is evalauted quantitatively within the framework of the electron theory of catalysis, taking into account the electronic characteristics of the solid's surface. The relation between the activation of the catalysts and the energy transfer is investigated. (tr-auth)

**32179** GAMMA RADIATION INITIATED POLYMERIZATION OF FLUOROMONOMERS. II. COPOLYMER OF CHLOROTRIFLUOROETHYLENE AND ETHYLENE. P. J. Manno (Continental Oil Co., Ponca City, Okla.). 3p. (CONF-39-10)

From American Nuclear Society Meeting, Salt Lake City, June 1963.

The radioinduced copolymerization of chlorotrifluoroethylene and ethylene was studied. The polymerization rate increased with time and radiation intensity, and the G-values after 50% polymerization varied from 13,000 at $10^5$ rep/hr to 25,000 at $6 \times 10^3$ rep/hr. The polymerization rate is proportional to the 0.7 or 0.8th power of the radiation intensity. The polymerization reaction is highly exothermic, and the optimum conditions for the best polymer properties occurred in a stirred autoclave cooled to 0°C containing a monomer–water mixture and irradiated at $10^4$ rep/hr. Catalytic polymerization was also studied, and the economics of or the preparation of the copolymer by catalytic and radiation processes is discussed briefly. (D.L.C.)

**32180** METHOD FOR PREPARING AND PRODUCING RADIOACTIVE IODINE. G. Irving Gleason (to Abbott Labs.). German Patent 1,145,146. Mar. 14, 1963. Filed June 22, 1961.

$I^{131}$ is produced by bombarding a Te target with a flux of neutrons. When absorbing a neutron, $Te^{130}$ is transformed into the isotope $Te^{131}$ which disintegrates into $I^{131}$ by emitting beta particles. It is proposed to use m-telluric acid as target material at a temperature of 160°C. The irradiated target material is dissolved in water, the watery solution being acidified with a concentrated, nonvolatile mineral acid. Finally, the $I^{131}$ can be isolated by distillation. (Gmelin Inst.)

**32181** CROSS LINKING OF FATTY POLYAMIDES WITH IONIZING RADIATION. Raymond F. Paschke (to General Mills, Inc.). U. S. Patent 3,098,806. July 23, 1963. Filed Dec. 10, 1959.

If fatty polyamides are subjected to ionizing radiation such as $\gamma$ rays, cross linking occurs, which results in raising the melting point of the polyamides. Polyamides with melting points below 130°C used here are those prepared from the amidic fatty acids, the epoxidized fatty acids, and the polymeric fat acids. Five examples of irradiation of polyamides and the effect of irradiation on properties are given. Greater strength and hardness were accomplished as well as raised melting points. (A.G.W.)

## Raw Materials and Feed Materials

**32182** (GTR-17) DIRECT CONVERSION OF URANIUM TETRAFLUORIDE TO URANIUM CARBIDE. Final Technical Report, GTR-62-4571, July 1, 1961–June 30, 1962. B. D. Reznik and R. M. Powers (General Telephone and Electronics Labs. Inc., Bayside, N. Y.). May 1963. Contract AT(30-1)-2883. 39p.

The feasibility of a new and potentially low cost method for converting uranium fluorides to uranium carbide was established. The reaction, $UF_4 + Si + C \rightarrow UC + SiF_4\uparrow$, was found to proceed readily in the temperature range of 1200 to 1800°C at pressures of 500 microns to 375 mm Hg. The optimum conditions for producing high purity uranium carbide was found to be 24 hours at 1350°C under a system pressure of 500 microns. The uranium carbide product was found to contain residual fluorine and silicon contents below 100 to 150 ppm respectively. Oxygen and nitrogen contents were below 800 ppm and carbon content was found to be $5.0 \pm 0.1$ wt %. The density of the as-produced powder averaged 13.9 g/cc. Preliminary studies were also initiated on the reaction of uranium tetrafluoride with silicon in a furnace in which the rates of silicon tetrafluoride evolution could be closely monitored in order to gain insight into the reaction mechanism. (auth)

**32183** FRENCH URANIUM TECHNOLOGY AND ITS INDUSTRIAL PROTECTION. L. Cousson. Bull. Inform. Sci. Tech. (Paris), No. 71, 53-63(Apr. 1963). (In French)

The French metallic uranium industry started with the construction (1946 and 1947) of the first parts of the Le Bouchet Plant. Its development from 1947 to 1957 was only very gradual, linked as it was to the demand for uranium. This relatively slow development allowed research workers time to devise perfections immediately applicable, at a reasonable cost, to an installation which slowly progressed from the pilot-plant to the semi-industrial stage, and then to full industrial production. Some figures are presented to give an idea of this development. (auth)

**32184** RESEARCH ON URANIUM MINERAL BENEFICIATION. PART I. THE BEHAVIOR OF SOME COMMONLY-OCCURRING URANIUM MINERALS IN HIGH-TENSION SEPARATION. S. V. Vijaykar and K. K. Majumdar. Mining Mag. (London), 107: 9-11(July 1962).

The behavior of U minerals such as uraninite, curite, and uranophane, was observed in a high-tension separator under different fields including electrostatic-convective, convective and electrostatic fields. The effect of composition on conductivity was also studied. (Rev. Metal Lit., 19: No. 10, Oct. 1962).

**32185** RESEARCH ON URANIUM MINERAL BENEFICIATION. PART II. FLOTATION OF A LOW-GRADE URANIUM ORE FROM KERUADUNGRI, S. BIHAR. T. R. Madhavan and K. K. Majumdar. Mining Mag. (London), 107: 11-14(July 1962).

An investigation was made of U ore flotation using various fatty acids, soaps, and petroleum sulfonate. The effects of grinding, pH, conditioning time, pulp density, depressants and activators were also studied. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**32186** FORECAST OF TRENDS IN URANIUM COSTS AND THEIR INFLUENCE ON FUELLING COSTS. A. F. Lowell. 13p. (CONF-9-6)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

The reserves of U ore in the free world are summarized. Forecasts of supply and demand suggest that known reserves of $U_3O_8$ that can be economically produced for sale at prices up to $8.00/lb will be used up in about 20 years. The U mining industry operates under a dual-pricing system, selling large volumes to the government at high prices and low volumes on the open market at much lower prices. As the influence of the government declines, the open market prices must rise, but they do not need to rise, excessively. No major ore shortage is forseeable, if

exploration for new ore reserves is resumed. When more normal market conditions prevail, the price of $U_3O_8$ is expected to stabilize around $8.00/lb, but this would account for only ~⅓ of the cost of the fuel elements. (M.P.G.)

**32187** THE PRECIPITATION OF DOUBLE FLUORIDE SALTS OF URANIUM. C. W. A. Muir (Government Metallurgical Lab., Johannesburg). 26p. (CONF-49-2)

From International Symposium on Unit Process in Hydrometallurgy, Dallas, Feb. 1963.

Bench-scale kinetic tests were conducted to study the reduction and precipitation reactions involved in the preparation of ammonium uranous fluoride from high-purity uranyl nitrate solutions. Sulphur dioxide and formic acid were used to form the active reducing agent, nascent hyposulphite ion. The reduction was affected in the presence of ammonium fluoride, resulting in the precipitation of the highly insoluble double salt. It was found that uranium was precipitated at a constant rate throughout the progress of the reaction. It is postulated that the reducing agent was continuously regenerated, and that this reaction was rate controlling. As a result of this study, a reaction mechanism is proposed. (auth)

**32188** URANIUM ORE-CARBONATE LEACH PROCESS INVOLVING ADDITION OF CHLORINE, ALKALI METAL HYPOCHLORITE OR AMMONIUM HYPOCHLORITE TO PREGNANT LIQUOR DERIVED THEREFROM. Clifford J. Lewis (to Phillips Petroleum Co.). U. S. Patent 3,098,707. July 23, 1963. Filed Aug. 25, 1958.

It is proposed that the recovery of U from its ore may be increased by contacting liquid formed in the carbonate leach process with chlorine or certain hypochlorites. The U ore is leached with a basic carbonate solution and the resulting slurry is filtered to produce a pregnant liquor containing soluble U. Chlorine gas may be bubbled through the pregnant liquor or an alkali metal hypochlorite or ammonium hypochlorite may be added. After sufficient contact time, the U is precipitated by addition of a hydroxide. (A.G.W.)

**32189** URANIUM OXIDE AND THORIUM OXIDE RECOVERY. Raymond A. Foos and Edgel P. Stambaugh (to National Distillers and Chemical Corp.). U. S. Patent 3,098,708. July 23, 1963. Filed Aug. 26, 1959.

A method for recovering finely divided thoirum and uranium oxides from acidic solutions is described. The process involves heating the U- or Th-containing feed solutions at temperatures of 170 to 250°C under a pressure of 100 to 400 psi. The treatment is continued for 2 to 60 min, usually about 5 to 10 min. Uranium oxide and/or thorium oxide hydrate precipitate from the solution and have an average particle size in the range of 0.5 to 20 $\mu$. The precipitate is recovered by filtration after the pressure is released. Any conventional type pressure vessel can be used, and the process can be continuous or batchwise. Inert solid materials may be added to the feed solution in order to prepare heterogeneous finely divided oxide-additive mixtures. (A.G.W.)

## Separation Processes

**32190** (DP-700) SOLVENT EXTRACTION DATA FOR PLUTONIUM. A Compilation of Data in the Literature. Linda Lou Smith (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Dec. 1962. Contract AT(07-2)-1. 272p.

Solvent extraction data for plutonium were obtained from a literature survey. Extraction coefficients for the distribution of Pu(III), (IV), and (VI) in a large number of aqueous and organic systems are presented in tabular and graphical form. The significance of the various data is discussed. (auth)

**32191** (DP-818) EXTRACTION BEHAVIOR OF ZIRCONIUM AT SHORT RESIDENCE TIMES. Albert A. Kishbaugh (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). May 1963. Contract AT(07-2)-1. 18p.

Tracer-level studies in a rotary extractor indicated that low temperatures (25°C) and short residence times (50 seconds) of solvent in the scrub section of the extraction bank in the enriched uranium process will result in poor gross gamma decontamination (mostly removal of zirconium-niobium). However, a flowsheet with high uranium saturation and operation at 60°C will completely offset this detrimental effect. (auth)

**32192** (DP-839) PROCESSING OF POWER REACTOR FUELS. Twenty-Second Quarterly Progress Report, January 1 to April 1, 1963. A. A. Kishbaugh, comp. (Du Pont de Nemours (E. I.) & Co. Savannah River Lab., Aiken, S. C.). Contract AT(07-2)-1. 10p.

During the electrolytic dissolution of simulated Hallam reactor fuel in nitric acid at 60°C, sodium was dissolved safely at 1.2 grams per minute, which is ten times the rate previously demonstrated. Extrapolating this rate to a 10,000-amp plant dissolver having two baskets in series indicates that a processing rate of 0.5 metric ton of uranium per day is feasible for Hallam fuel and for the blanket assemblies from the Fermi reactor. The development program on electrolytic dissolution at the Savannah River Laboratory is being concluded, and a summary report will be published. Laboratory tests showed that dissolution of zirconium-containing fuel in a 304L stainless steel vessel may be feasible with a mixed dissolvent of hydrofluoric acid, aluminum nitrate, and nitric acid. (auth)

**32193** (ORNL-TM-637) PREPARATION OF ESSENTIALLY PURE LITHIUM FLUORIDE: REMOVAL OF MAGNESIUM, BY R. F. APPLE. J. C. White (Oak Ridge National Lab., Tenn.). Aug. 2, 1963. Contract W-7405-eng-26. 3p.

A method is described for preparing essentially pure LiF, utilizing LiOH as the starting material. Magnesium is removed from a solution of the LiOH by extracting it as a magnesium-perfluorooctanoic acid complex with ethyl ether, after which the lithium is precipitated as LiF containing less than 15 ppm of magnesium. Precautions are given for preventing contamination by magnesium introduced as an impurity in reagents. (auth)

**32194** (TID-19068) ION EXCHANGE SEPARATION OF URANIUM AND THORIUM IN NON-AQUEOUS AND MIXED MEDIA. Johann Korkisch (Vienna. Universität. Analytisches Institut). Apr. 1963. Contract IAEA 67/US. 54p.

The adsorption behavior of uranium, thorium, and other elements on a strongly basic anion exchange resin in ketone, ether, and alcohol media containing hydrochloric or nitric acid is described. Based on these results separation methods for uranium, thorium, and other elements in such media were developed. Special attention was given to the adsorption and separation possibilities of uranium and thorium from the rare earths for which a new spectrophotometric method for the final determination was developed. (auth)

**32195** (KFK-tr-130) SELEKTIVE IONENAUSTAUSCHER. II. SPEZIFISCHER AUSTAUSCHER FUR

WISMUT. (Selective Ion Exchange. II. Specific Exchange for Bismuth). A. Lewandowski and V. Szczepaniak. Translated into German by Franz Weitzenmiller (Kernreaktor Bau- und Betriebs-Gesellschaft m.b.H., Karlsruhe, Germany) from Chem. Anal. (Warsaw), 7: 593-7(1962). 6p.

An ion exchanger is described that selectively retains bismuth in the form of the anion $BiI_4^-$. Nicotine was incorporated in the ion exchanger so that it could form an orange-red precipitate with the soluble bismuth iodide. Results are given for the separation of Bi from Pb, Sn, Zn, Mg, and Fe. (M.C.G.)

**32196** (UCRL-Trans-973) ELECTROPHORESIS OF COMPLEX COMPOUNDS. III. SEPARATION OF SOME RARE-EARTH ELEMENTS BY ELECTROPHORESIS ON PAPER IN A MEDIUM OF NITRILOTRIACETIC ACID. V. Knoblokh and Rhen Te-Hou (Joint Inst. for Nuclear Research, Dubna, U.S.S.R. Lab. of Nuclear Reactions). Translated for Univ. of California Lawrence Radiation Lab., Berkeley from report JINR-P-1174. 1963. 13p.

A possibility is shown for preliminary calculations of the electrophoresis processes in nitrilotriacetic acid. These calculations may be used for the selection of complex-forming material and for determining the separation conditions of chemically similar elements. A graphical method is given for the determination of equilibrium constants and of types of reactions in which complex compounds are formed. (auth)

**32197** RECENT ADVANCES IN CONNECTION WITH THE SEPARATION OF RARE EARTHS. D. L. Massart (Rijksuniversiteit, Ghent). Ind. Chim. Belge, 28: 629-35 (June 1963). (In French)

A survey is given of recent chromatographic work in connection with the separation of rare earths. The following points are discussed: separations carried out by means of cation exchangers, anion exchangers, inorganic exchangers, and extraction exchange. The possibilities of the extraction-exchange method are discussed more fully in a short survey of the liquid extraction techniques. (auth)

**32198** AN ION EXCHANGE UNIT FOR RADIOCHEMICAL SEPARATION. W. J. Mottel and J. F. Proctor (E. I. du Pont de Nemours & Co., Inc., Aiken, S. C.). Ind. Eng. Chem., 55: No. 8, 27-9(Aug. 1963).

A description is given of three ion exchange units which were constructed for large-scale separations in reactor fuel processing. The units are based on the unitized concept of arrangement using steel frames. Solutions are transferred between vessels by steam jets or air lifts, and the resin is suspended in a solution of the same specific gravity during the charging and discharging of the columns. The service piping, process vessels, and venting are described. (D.L.C.)

**32199** HALOGENATION METHODS FOR REPROCESSING OF NEUTRON-IRRADIATED NUCLEAR FUELS. D. Naumann (Zentralinstitut für Kernphysik, Rossendorf, Ger.). Kernenergie, 6: 243-51(June 1963). (In German)

The use of halogenation methods in processing irradiated fuels is discussed. Topics covered include: the Zircex process, fluorination process, halide scorfication and halide conversion cycle, special processes for ceramic fuel materials, and corrosion problems in halogen processes. (M.C.G.)

**32200** REPROCESSING OF $UO_2$-DISPERSED GRAPHITE FUELS. II. THE BEHAVIOR OF NON-GASEOUS FISSION PRODUCTS IN NITRIC-ACID-LEACH PROCESS. Kazumi Iwamoto, Fumiaki Kobayashi, and Junichi Shimokawa (Japan Atomic Energy Research Inst., Tokyo). Nippon Genshiryoku Gakkaishi, 5: 461-6(June 1963). (In English)

Experiments were done to investigate the behavior of non-gaseous fission products in nitric-acid-leach process in which the conditions of the leaching and postirradiation heating were varied for the irradiated graphite-base fuel element in which most of the fission products had been introduced into the graphite matrix by fission recoil process. The temperature and time of the postirradiation heating were found to be most effective to drive off the fission products from the graphite. A fast and a slow migration step were observed for the migration of the fission products through the graphite crystal. The former was thought to represent the transfer process of all the fission products that may migrate through the graphite crystal in the temperature region below the heating temperature, and the latter the one of the fission products which may migrate only at the temperature of the postirradiation heating. The migration behavior was independent of the particle size of graphite. (auth)

**32201** PLANTS FOR THE WET PROCESSING OF IRRADIATED FUEL ELEMENTS. Ugo Miranda (Euratom, Brussels). Riv. Ing. Nucl., 1: 15-20(Jan.-Feb. 1963). (In Italian)

A brief description is given of the industrial procedures for the wet processing of irradiated fuel elements with natural and enriched U. The general aspects of the problems of handling hot fuel elements are indicated. The chemical procedures used and the characteristics of the plants are discussed. (J.S.R.)

**32202** ON THE MECHANISM OF RARE EARTH SEPARATION BY ION EXCHANGE. L. I. Martynenko (Moscow State Univ.). Zh. Neorgan. Khim., 8: 1535-7(June 1963). (In Russian)

Distribution of Nd and Pr between $(LnA)^-$ solution (where $A^-$ is ethylenediaminetetraacetic acid) and cation was studied in order to determine the effects of resin absorbed complex on the ion exchange process. It was found that under dynamic conditions the absorption of complexes by resin and the K Pr/Nd separation differ greatly from theoretical data and the ion separation of rare earths is strongly affected by side reactions, especially, by absorption reaction of anion complex $(LnA)^-$ by a cation. (R.V.J.)

**32203** INTEGRATED NUCLEAR POWER AND FUEL REPROCESSING STATIONS. John K. Davidson (Allis-Chalmers Mfg. Co., Milwaukee). 9p. (CONF-15-1)

From American Power Conference Meeting, Chicago, Mar. 1963.

The economic and logistical advantages and drawbacks of the integration of fuel reprocessing facilities with a group of neighboring large power reactors are compared with those of centralized reprocessing facilities. The pilot-scale Italian PCUT integrated station is described. (T.F.H.)

**32204** ADSORPTION OF CERIUM VALUES FROM AQUEOUS SOLUTIONS. Francis P. Roberts (to U. S. Atomic Energy Commission). U. S. Patent 3,100,683. Aug. 13, 1963.

Cerium can be removed from aqueous nitric acid (2 to 13 M) solutions by passing the latter over a $PbO_2$-containing anion exchange resin. The cerium is taken up by the resin, while any lanthanides, yttrium, and strontium present remain in the solution. (AEC)

**32205** RECOVERY AND SEPARATION OF LITHIUM VALUES FROM SALVAGE SOLUTIONS. D. L. Hansford and E. W. Raabe (to U. S. Atomic Energy Commission). U. S. Patent 3,101,246. Aug. 20, 1963.

Lithium values can be recovered from an aqueous basic solution by reacting the values with a phosphate salt soluble in the solution, forming an aqueous slurry of the resultant aqueous insoluble lithium phosphate, contacting the slurry with an organic cation exchange resin in the acid form until the slurry has been clarified, and thereafter recovering lithium values from the resin. (AEC)

# ENGINEERING AND EQUIPMENT

## General and Miscellaneous

*Refer also to abstract 33159.*

**32206** (ACNP-63021) STEAM SEPARATION TECHNOLOGY UNDER THE EURATOM PROGRAM. Quarterly Progress Report, April 1, 1963–June 30, 1963. (Allis-Chalmers Mfg. Co. Atomic Energy Div., Milwaukee). July 10, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(11-1)-1186. 137p. (EURAEC-743)

Installation of the test equipment and checkout of the steam-water test facility's controls for the first series of tests was completed with favorable results. Tests to determine the relation between steam void fraction and superficial steam velocity are complete through the pressure range of 600 to 2,000 psig. A correlation equation which relates steam void fraction to basic system parameters is reported. The liquid level detector is in operation, and preliminary tests were performed. Detector performance is as predicted. Void fraction measurements in the downcomer region of the reactor mock-up were completed. Results show that by using a reduced area riser, carryunder in a natural separation system can be greatly reduced. The prediction equation which relates riser geometric parameters and fluid properties to downcomer voids is refined to include results of the large diameter tests. The resulting equation more accurately describes large diameter risers. Development and testing of the 8- and 10-inch diameter centrifugal downflow separators were completed. The best separator tested to date has a flow capacity of 2800 gpm with 0.75% carryunder. Development of an analytical approach to design of this type of separator for a given set of pressure and flow conditions is in progress. (auth)

**32207** (DMIC-Memo-167) NOTES ON LARGE-SIZE FURNACES FOR HEAT TREATING METAL ASSEMBLIES. H. J. Hucek, A. R. Elsea, and A. M. Hall (Battelle Memorial Inst. Defense Metals Information Center, Columbus, Ohio). May 24, 1963. Contract AF33(616)-7747. 12p.

A revision of DMIC-Memo-63.

The availability and location of extra-large-capacity furnaces for heat treatment of metal assemblies are summarized. Most of the furnaces are bottom-open gantry furnaces using an endothermic protective atmosphere. The largest heat-treating furnaces now available were built specifically to heat treat cases with diameters up to 120 in. (M.C.G.)

**32208** (GDC-63-140) DEVELOPMENT OF A HIGH-TEMPERATURE, NUCLEAR-RADIATION-RESISTANT PNEUMATIC POWER SYSTEM FOR FLIGHT VEHICLES. Quarterly Report, March 25, 1963–June 24, 1963. (General Dynamics/Convair, San Diego, Calif.). Contract AF33(616)-7582. 61p.

A revised work statement for Phase II, "Design and Experimental Testing of the Turbocompressor," was prepared, and work on the preliminary study phase was initiated. A material wear survey was completed and is submitted. These data on the most promising material combinations, surface coatings, and lubricants recommended for use over extreme temperature ranges will be used as a guide in selecting suitable materials for the compressor air bearing. Experimental evaluation of both pneumatic filters (including a sustained high-temperature flow test on Unit No. 1) was completed. In regard to the pressure regulator, some delay occurred due to an unsatisfactory weld of the pilot bellows. The problem was resolved and the Model X regulator is now undergoing experimental testing. (auth)

**32209** (SC-4781(RR)) SLIDE-DAM CONSTRUCTION EMPLOYING NUCLEAR EXPLOSIVES. G. A . Young (Sandia Corp., Albuquerque, N. Mex.). May 1963. Contract [AT(29-1)-789]. 81p.

The construction of slide dams through the use of nuclear explosives, one of the uses of nuclear explosives being considered in the Plowshare program was examined. Requirements were established for nuclear slide-dam construction based upon experience with conventional dams. The information to be required from experimental studies was determined. The characteristics of conventional earth and rock-fill dams were examined along with the characteristics of natural landslide dams. This examination led to the conclusion that, on the basis of present knowledge, a favorable site can be developed by nuclear means, though not in the most economical manner. For more direct and reliable design, a better knowledge of slide mechanics and slide initiation is required. A program of laboratory and field experiments aimed at gaining this knowledge was therefore developed. Specific problems of slide initiation with nuclear explosives were considered, and further experiments recommended. (auth)

**32210** HOW MUCH FUTURE FOR ELECTRIC PROPULSION? John C. Evvard (Lewis Research Center, Cleveland). Astronaut. Aerospace Eng., 1: No. 7, 92-7(Aug. 1963).

General conclusions concerning the potential of electric propulsion systems for near-earth and deep-space missions are discussed. The need for a lightweight, reliable space power system is considered. Power plant weight vs. trip time parameters for various planetary missions are presented. The Rankine-cycle, Brayton-cycle, and thermionic-reactor power systems are discussed. The effect of meteoroid penetration on power plant weight is also considered. (C.E.S.)

**32211** CONSTRUCTION OF A HOT LABORATORY. Karl-Erwin Betzler. Kerntechnik, 5: 254-6(June 1963). (In German)

An outline is given of the steps of the development in which the hot laboratory of the Munich Research Reactor has been erected. The individual building and equipment parts in their special assembly are particularly described. (auth)

**32212** LIGHT IMPULSE GENERATORS IN THE NANOSECOND REGION. G. Pfeffer, H. Lami, G. Laustriat, and A. Coche (Centre de Recherches Nucléaires, Strasbourg). Nucl. Instr. Methods, 23: 74-6(May 1963). (In French)

Optical and electrical properties of hydrogen flash tubes are described. These millimicrosecond duration light sources are suitable for testing fast photomultipliers and for investigating decay times of organic scintillators. (auth)

**32213** VACUUM CATHODIC ETCHER. (Engineering Materials). (E. I. Du Pont de nemours and Co., Aiken, S. C.). (CAPE-1015)

The remotely controlled vacuum cathodic etcher described in 10 drawings is used to etch irradiated U and U alloys in hot cells for metallographic examination. The

vacuum pump, etching chamber, and operating controls are located in the hot cell. Manipulators operate this metallurgical equipment. The argon gas supply and electrical equipment are located outside of the cell. A specimen to be etched is used as the cathode in a glow discharge chamber and is bombarded with positive ions. An Al water-cooled bell jar is used as the chamber and an Al anode, mounted in the bell jar, is used to produce the positive ions. The metal taper joint for the thermocouple gauge should be replaced with a screwed pipe fitting. (F.E.S.)

**32214** FORECAST OF TRENDS IN DESIGN AND COST OF FOSSIL-FUELED PLANT. W. K. Carruthers (Montreal Engineering Co. Ltd.). 37p. (CONF-9-11)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

The fossil-fueled thermal generating plant, with which nuclear power plants must compete within the next decade, is forecast. Trends in major variables, such as fuel, labor and materials, plant efficiency, capital costs, and production costs, are established from a study of the 10 most efficient plants in the United States for the years 1952 to 1961 inclusive. It is predicted that the competitive fossil-fueled plant will have a 500 Mw capacity per unit and will operate at 2400 psig/1000°F with a heat rate of 9000 Btu/kwh. In 5 years the plant will produce power for $17.00/kw year plus 2.70 mills/kwh net, assuming fuel costs at 30¢/million Btu and cost of money at 10%. (M.P.G.)

**32215** PERFORMANCE OF MECHANICAL SEALS FOR PRIMARY COOLANT PUMPS. P. J. Fulford (Atomic Energy of Canada Ltd., Toronto). 15p. (CONF-9-14)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

The experience of AECL with high-pressure pump-shaft seals is reviewed, and in this light important operating parameters and several variations in design are discussed. The requirements for such seals are outlined. (auth)

**32216** APPARENT COST TRENDS IN HYDRO-ELECTRIC DEVELOPMENTS AND THE TRANSMISSION OF ELECTRIC POWER. D. M. Farnham (Quebec Hydro Electric Commission). 11p. (CONF-9-12)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Energy costs from modern hydro-electric plants are estimated to be ~3 to 3½ mills/kwh at generator terminals. Since the plants have to be built where the hydro-electric potentials exist, the cost of transmitting the power is important. Graphs showing the annual cost/kwh at 60% load factor for voltages of 132, 300, and 735 kv and the transmission costs in mills/kwh/100 miles of transmission distance as a function of voltage are presented. The upper voltage limit for 60-cycle transmission is estimated to be ~800 to 900 kv. Direct current transmission may prove to be the economic answer to the problem of moving large quantities of power long distances. (M.P.G.)

**32217** THE CONTROLLED-GROWTH COLLOIDAL ION SOURCE. A. Lucile Cox and Stanley Harrison (Ion Physics Corp., Burlington, Mass.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63049-63, 12p. (CONF-10-58)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

For propulsion purposes, a colloidal ion source should produce particles with a very limited spread of charge-to-mass ratios between $10^2$ and $10^5$ coul/kg at current densities of at least 0.1 ma/cm$^2$. To meet these requirements the controlled-growth colloidal ion source was planned to provide for growth of ions by condensation from an accompanying supersaturated vapor. Growth of the colloidal ions is controlled by a retarding field that governs the velocity of the charged particles through the growth region. Although the processes involved in the controlled-growth colloidal ion source are interdependent, initial experimental studies were necessarily confined to separate investigations of ionization and mass flow. Useful studies of the growth process require a partially-ionized, supersonic, supersaturated jet. Several ionization techniques were evaluated under the conditions required for operation of the controlled-growth colloidal ion source. The ability of various nozzle designs to produce a collimated jet of vapor was also studied. In some experiments, the presence of electrons in the growth region and the effects of retarding and focusing fields on the ion beam were examined. The nucleation process, which must precede particle growth, was analyzed. This analysis indicates that mercury may best achieve the required preferential ionic nucleation. (auth)

**32218** INCLINATION AND ECCENTRICITY CHANGES EFFECTED BY LOW-THRUST PROPULSION SYSTEMS. Constance J. Golden (Lockheed Missiles and Space Co., Palo Alto, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63039, 12p. (CONF-10-59)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Change in orbit inclination and eccentricity are often involved in missions performed in a strong central force field by low-thrust, power limited propulsion systems. These changes are analyzed for constant thrust acceleration using standard expressions from celestial mechanics. Inclination change is discussed first with respect to a pure binormal thrust program and a thrust program producing maximum simultaneous change of inclination and radius. From general expressions for the change in inclination per revolution produced by each thrust program, the mission time and inclination change produced during a transfer from one circular orbit to another are determined in closed form. These expressions lead to a condition that shows that the optimum steering program is independent of the thrust acceleration applied. The optimization expressions developed for a circular orbit transfer are applied to the specific example of the transfer to the 24-hour synchronous orbit while executing a 30° plane change. Two programs for changing eccentricity are discussed; one is derived by maximizing standard expressions of celestial mechanics, while the thrust direction of the other is always perpendicular to the line of apsides. By comparing the expressions derived for the change in eccentricity per revolution produced by each program, the fixed-direction program is found to be more effective than the first for eccentricities larger than .26. The semi-major axis remains nearly constant for the fixed-direction program, so the time required to reduce any eccentric orbit to a circular one may be given in analytic form. (auth)

**32219** RESULTS OF SATELLITE RAISING AND ORBIT TRANSFER STUDIES FOR LOW POWER ELECTROTHERMAL ARC-JET PROPULSION SYSTEMS. Frederic E. Marchand, Paul D. Arthur, and Owen J. McCaughey (Plasmadyne Corp., Santa Ana, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63010, 14p. (CONF-10-38)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

The satellite raising (or orbit transfer) applications of low power electrothermal arc-jet engines are considered. Advantages and disadvantages of using solar panel-electrothermal propulsion for satellite raising are briefly discussed, and parametric mission study methods and results are reported for a specific mission of raising a satellite from an inclined parking orbit to a synchronous equatorial orbit. Effects of independently varying the following parameters were investigated: propellant type, engine power level, power supply specific weight, thruster specific impulse, and payload. Ascent time and parking orbit altitude were the dependent variables. Arc-jet engine design and development goals, in terms of propellant type, power level, and specific impulse, are optimized for the specified mission. Results indicate an optimum power level between 1.5 and 3 kw, based on projected power supply specific weights, and further indicate potential advantages of ammonia over hydrogen as the propellant, provided required engine life can be obtained. Principal potential advantage of ammonia over hydrogen is the much shorter ascent time required, while principal disadvantage involves the more severe thruster development problems. Criteria are suggested for selecting design and development goals for engine specific impulse. (auth)

**32220** ELECTRIC PROPULSION FOR CONTROL OF STATIONARY SATELLITES. Roland Boucher (Hughes Aircraft Co., Culver City, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63009, 44p. (CONF-10-37)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

The application of electric propulsion engines to attitude control and stationkeeping of 24-hour stationary satellites is analyzed and compared with the performance of contemporary cold gas, monopropellant, and bipropellant propulsion systems. Both a 500-pound spin-stabilized and a 1500-pound three-axis controlled satellite compatible with current boost vehicles are examined, and each type of propulsion system compared as a function of mission duration and maneuver requirements. Solar electric propulsion is shown to be superior to chemical propulsion for long term stationkeeping and three-axis attitude control of the larger satellite. Cold gas and chemical propulsion are superior for attitude control and provide strong competition for electric propulsion in the stationkeeping of the smaller spin-stabilized satellite. (auth)

**32221** THE ELECTRIC SPACE CRUISER FOR HIGH ENERGY MISSIONS. Robert J. Beale, Evelyn W. Speiser, and James R. Womack (California Inst. of Tech., Pasadena). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63007-63, 11p. (CONF-10-35)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Basic system requirements for spacecraft capable of significant, unmanned exploration of the entire solar system are thrust devices efficient in the specific impulse range of 6000-12,000 sec, a nuclear turboelectric powerplant of 500 kwe weighing about 14 lb/kw, and a total spacecraft weight of 20,000 lb. A brief systems description of the spacecraft is presented. For discussion purposes, a Jupiter orbiter mission is used as an example. The modes of operation for the spacecraft are reviewed and a summary of major subsystem weights is shown. Other study areas explored and reported indicate a typical power profile for the mission, micrometeoroid armor requirements, the effect of nuclear shielding tradeoffs, and the major factors determining the selection of the optimum power level. (auth)

**32222** UTILIZATION OF ELECTRIC THRUST DEVICES FOR SPACECRAFT PROPULSION. Jerome H. Molitor (Hughes Research Labs., Malibu, Calif.). New York, American Society of Mechanical Engineers, (1963), Preprint 63-AHGT-46, 7p, $1.00. (CONF-7-2)

From Aviation and Space, Hydraulic, and Gas Turbine Conference and Products Show, Los Angeles, Mar. 1963.

The utilization of electric thrust devices for interplanetary spacecraft is discussed. Two missions, a Mars orbiter and a Venus orbiter, are analyzed to determine the requirements placed on an electrical propulsion system by interplanetary spacecraft. Terminal mass-to-initial mass ratios are presented as a function of total flight time with initial acceleration and specific impulse as parameters. The mission requirements are then translated into desired engine-performance characteristics. A description of a cesium surface contact ion thrust device is given and the power efficiencies of present and advanced engines are presented as a function of specific impulse. The optimum specific impulse, as well as the required power-to-thrust ratio for each mission, is then defined. Finally, the weights and sizes of ion thrust modules are estimated and possible module arrays meeting spacecraft integration requirements are discussed. (auth)

**32223** SUMMARY AND CRITICAL EVALUATION OF THE MISSION CAPABILITIES OF ELECTRIC PROPULSION. Ronald S. H. Toms and Stanton L. Eilenberg (Electro-Optical Systems, Inc., Pasadena, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63008B, 23p. (CONF-10-36).

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

A method of correlating many of the results for the mission capabilities of electric propulsion by plotting payload against a mission difficulty parameter defined as the velocity increment from an earth orbit that would be required for a minimum-energy impulsive transfer is presented. The locations of some of the boundaries are discussed, and propulsion system selection maps are presented for low time and cost missions and for low cost slow missions. The published results of several authors are extrapolated and plotted on the maps, showing fair agreement. Care was taken to be objective with respect to the favorable aspect of chemical and nuclear-thermal propulsion. The superiority of electric propulsion became obvious for all manned missions beyond the moon and for a large class of unmanned missions to the planets. A very significant conclusion is reached from the analysis that even with relatively heavy power supplies the electric rocket has a much higher potentiality than is generally believed, and strong evidence in the case for electric propulsion is presented. (auth)

**32224** THE DESIGN AND CONSTRUCTION OF A LARGE SUPERCONDUCTING MAGNET. W. A. Stewart, D. T. Beecher, R. E. Kothmann, and H. W. Szymanowski (Westinghouse Electric Corp., Pittsburgh). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63058, 45p. (CONF-10-22)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

The critical magnetic field characteristics of $Nb_3Sn$ and Nb–25% Zr superconductors are outlined. The design of a weight-optimized superconducting magnet for magneto-

hydrodynamic power production in space applications is described. (T.F.H.)

**32225** PHYSICAL PROCESSES IN A CO-AXIAL PLASMA GUN. T. J. Gooding, B. R. Hayworth, and R. H. Lovberg (General Dynamics/Astronautics, San Diego, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63004, 19p. (CONF-10-51)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Design problems generated by physical processes in coaxial plasma guns for space-propulsion applications are outlined. Calculations are given using the example of $N_2$ as the propellant. (T.F.H.)

**32226** DOES RING WEAR PREDICT CYLINDER WEAR? FIELD MEASUREMENTS COMPARED WITH LABORATORY RADIOTRACER DATA. P. E. Pfeifer and W. J. Braun. New York, Society of Automotive Engineers, Inc., 1963, Preprint 715C, 11p, $1.00. (CONF-96-1)

From International Summer Meeting, Montreal, June 1963.

A process is described for irradiating a cylinder liner so as to concentrate $Fe^{59}$ radioactivity (and a smaller amount of $Mn^{54}$) in the upper portion of the cylinder, providing a means of testing ring and cylinder wear by radioactive methods. Field test results show that wear at the upper limit of ring travel accounts for about 60% of cylinder wear. Laboratory experiments indicate that ring and cylinder wear relationship is affected by varying operating conditions. Possible anomalies in the ring and cylinder wear relationship warrant further investigation, and the radioactive technique presented simplifies and expedites such study. (auth)

**32227** DESIGN, PRODUCTION AND TESTING OF NUCLEAR VALVES FOR LIQUID COOLANT REACTORS. A. K. Velan (Velan Engineering Ltd., Montreal). 26p. (CONF-82-2)

The stringent requirements for leak tightness and material behavior of valves for reactor primary coolant systems are summarized. The design requirements are described: body-bonnet sealing, stem sealing, seat, etc. The nondestructive tests to be carried out on the valves are outlined. Finally, the clean conditions of the valves are considered. (D.L.C.)

**32228** IMPROVEMENTS IN OR RELATING TO JOINTS BETWEEN TUBULAR MEMBERS. Norman Battle (to Rolls-Royce Ltd.). British Patent 917,726. Feb. 6, 1963. Filed Sept. 9, 1960.

Several designs for joints between members having coaxial radially spaced cylindrical surfaces are patented. One design consists of a pair of frusto-conical rings arranged concentrically, the larger diameter end of one being adjacent to the smaller diameter end of the other. The rings are compressed axially so that the outer peripheries of the rings make sealing contact with adjacent surfaces. The other designs also incorporate seals of frusto-conical surfaces. The designs are applicable to joints between a fuel channel and the header tank of a reactor coolant system. (M.P.G.)

**32229** UNDERWATER STORAGE SYSTEM. Harold G. Quase (to Jet Fuel & Storage Co.). British Patent 930,740. July 10, 1963. Filed Nov. 22, 1960.

An underwater storage system for solid, liquid, or gaseous materials is patented. A plurality of closed portable containers are mounted underwater. A duct system connects some of the containers with a common duct to the water surface for filling and discharging the fluid contents of the containers. The containers can also be removed individually or in groups to a remote place for use of the contents or for refilling empty containers. Some of the containers may be formed of rigid material, and others may be made of flexible material, such as fabric-reinforced rubber. Methods of mounting, filling, and protecting the containers are discussed. The system is especially suitable for storing strategic materials, such as food or fresh water, and dangerous materials, such as petroleum products or explosives. (M.P.G.)

**32230** ELECTRICAL MEASUREMENTS THROUGH VESSEL WALLS. (to Atomic Energy of Canada Ltd.). British Patent 930,746. July 10, 1963. Priority date Apr. 13, 1961, United States.

An apparatus for measuring a property of a substance by electrical means without direct electrical connection is patented. A frequency-sensitive a-c bridge, such as a Wein bridge, is placed in contact with the substance. The bridge has a minimum output for one value of input frequency, and one element of the bridge is variable with the property to be measured and alters the frequency at which the output is a minimum. For example, to measure the temperature inside a closed vessel such as sealed reactor fuel elements, the variable elements in the bridge could be resistance thermometer bulbs. The source, a variable-frequency oscillator, for the input to the bridge and the detector for the output are coupled to the bridge by at least one transformer, so that no electrical wires are necessary between the source and detector and the measuring apparatus. (M.P.G.)

**32231** IMPROVEMENTS IN OR RELATING TO REMOTE OPERATING TOOLS. Laurence Jenks and Harry Sydney Gordon Viner. British Patent 931,441. July 17, 1963. Filed May 8, 1958.

An improved long-arm reacher or manipulator especially suitable for operating through a wall is patented. The reacher consists of an arm with a detachably mounted head on one end, an actuating member mounted at the other end, and a connecting mechanism to enable the actuating member to operate the engaging jaws on the head. A releasable coupling operatively couples the rod with the head and can be controlled from a point remote from the head. The detachable head makes it possible to use heads of different sizes or types. The head may be placed on the arm after the arm has been passed through the wall, making it possible to have only a small opening in the wall. The designs of the releasable head coupling and connecting mechanism are described. (M.P.G.)

**32232** IMPROVEMENTS IN OR RELATING TO REMOTE OPERATING TOOLS. Laurence Jenks and Harry Sydney Gordon Viner. British Patent 931,442. July 17, 1963. Filed May 8, 1958.

A device to mount a long-arm reacher or manipulator on top of a wall is patented. The device consists of a carriage, which is fitted to the top of the wall and may be moved along the wall, and a carrier, which engages the part of the manipulator crossing the wall and is connected to the carriage by pivoted links. When mounted in the device, the manipulator can be moved in any direction relative to the wall and can be pivoted about an axis transverse to the wall. (M.P.G.)

**32233** IMPROVEMENTS IN OR RELATING TO REMOTE OPERATING TOOLS. Laurence Jenks and Harry Sydney Gordon Viner. British Patent 931,443. July 17, 1963. Filed May 8, 1958.

The design of a long-arm reacher or manipulator with an angularly adjustable handle is patented. The reacher

consists of an arm with jaws at one end, for engaging or gripping an article, a handle unit at the other end to actuate the jaws, and an operating mechanism connecting the handles with the jaws. For convenience, the angular position of the handle relative to the arm is adjustable, but the adjustment does not affect the range of movement of the jaws. The handles are connected to the operating mechanism by a flexible connector such as a chain. Details in the design of the handles, locking mechanisms, and operating mechanisms are described. (M.P.G.)

**32234** IMPROVEMENTS IN OR RELATING TO REMOTE OPERATING TOOLS. Laurence Jenks and Harry Sydney Gordon Viner. British Patent 931,444. July 17, 1963. Filed May 8, 1958.

The design of a long-arm reacher or manipulator to handle articles separated from the operator by a wall is patented. The reacher consists of 3 arm sections rigidly connected together at angles such that the middle section extends across the top of a wall and the end sections extend down on each side of the wall. The arms are hollow, and connecting mechanisms within the arms operate jaws on one side of the wall when the actuating member on the other side of the wall is operated. Details of the connecting mechanisms and actuating member are described. (M.P.G.)

**32235** IMPROVEMENTS IN OBSERVATION PORTS FOR ENCLOSURES. Serge Clave and Marcel Clave. British Patent 931,474. July 17, 1963. Priority date Feb. 6, 1961, France.

An observation port is patented, which consists of a combination of field-reducing and field-enlarging optical systems. Magnification may be selected to meet the operator's requirements. The optical systems are plano-concave and plano-convex lenses separated by a distance equal to the difference between their focal lengths. The systems are afocal and optically aligned. The lenses in at least one system are separated by transparent blocks for protection against radiation. A second design includes a rotatably mounted optical assembly and a pivotally mounted mirror to provide a panoramic view of the inside of the enclosure. (M.P.G.)

**32236** IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTOR CORE STRUCTURES. Othniel Niel Banks (to United Kingdom Atomic Energy Authority). British Patent 931,676. July 17, 1963. Filed Sept. 5, 1960.

A patented reactor core structure consists of tubular coolant-conducting containers housing a plurality of fuel subassemblies. The fuel subassemblies can be individually withdrawn from the container, and a latching mechanism holds them in the container. A second latching mechanism holds the container in the reactor core. Since the fuel subassemblies can be removed from the container, the container can be reused, or the subassemblies can be "shuffled" for even burnup. The core design is suitable for a maritime reactor, since the containers cannot fall out of the reactor if the ship capsizes. (M.P.G.)

**32237** IMPROVEMENTS IN OR RELATING TO MANIPULATING DEVICES. Alan Ainsworth (to United Kingdom Atomic Energy Authority). British Patent 931,729. July 17, 1963. Filed Sept. 1, 1960.

A patented manipulator consists of an arm, a pivot which supports the arm and in which the arm slides, an arm extension, a joint between the arm and the arm extension, an operating mechanism at the free end of the arm, and a manipulating mechanism at the free end of the arm extension. The arm extension can be rotated about its own axis and can be pivoted about the joint by means of gears in the joint controlled by the operating mechanism. Greater access is obtained with this manipulator than with a common manipulating device. (M.P.G.)

**32238** MANIPULATORS FOR REPLACING FUEL UNITS IN A NUCLEAR REACTOR. Eugen Guidi (to Sulzer Freres). U. S. Patent 3,098,811. July 23, 1963. Priority date June 8, 1960, Switzerland.

A manipulator is described for connecting fuel units to and disconnecting fuel units from a device for securing the fuel units in the moderator part of a nuclear reactor. The manipulator is particularly adapted to operate securing devices of the type wherein the fuel unit is pressed against a stationary part mounted on the moderator unit, the pressure being produced by elastic means interposed between the stationary part and a movable locking part. The manipulator has two coaxial tubular elements axially movable relative to each other. One end of one of the tubular elements is provided with means to engage the movable part, and one end of the second tubular element is adapted to act on the elastic means of the securing device. The handling device forms a self-contained unit that can be transported from one securing device to another wherever a fuel unit must be replaced. (A.G.W.)

**32239** AN APPARATUS FOR MEASURING ANNULAR OFFSET BETWEEN A FIRST METAL TUBE AND A SECOND METAL TUBE SPATIALLY DISPOSED WITHIN THE FIRST TUBE. J. C. Spanner (to U. S. Atomic Energy Commission). U. S. Patent 3,100,281. Aug. 6, 1963.

An apparatus for measuring the amount of offset from concentricity between a first metal tube mounted within a second metal tube comprises a first pair of like sensing coils mounted diametrically opposite each other adjacent to the interior of the first tube and a second pair of sensing coils identical to the first pair of coils mounted diametrically opposite each other adjacent to the interior surface of the first tube and spatially displaced 90 degrees from the first pair of sensing coils. An a-c signal at a frequency such that the resultant electromagnetic energy from the sensing coils passes through the first tube and is essentially totally attenuated by the second tube is alternately provided to each pair of coils. Differential measurement of the effective impedance of the sensing coils in each of the pairs gives the amount of offset. (AEC)

**32240** BAYONET TYPE COUPLING WITH PIVOTED SEGMENT RELEASE MEANS. Ralph O. Work (to U. S. Atomic Energy Commission). U. S. Patent 3,100,655. Aug. 13, 1963.

A remotely actuated quick-disconnect electrical connector that comprises a pair of mating connector halves releasably retained together by an interlocking pin and groove arrangement is described. Pivotal latch means disposed in one of the connector halves adjacent the ends of the coupling grooves are normally held in an abutting relationship with the coupling pins by a slidable, lanyard actuated sleeve. The latch retains the pins in the grooves until the lanyard moves the sleeve and enables the latch to pivot out of the path of the pins for effecting disengagement of the coupling. (AEC)

## Heat Transfer and Fluid Flow

**32241** (ACNP-63020) INVESTIGATION OF VAPOR VOLUME FRACTION AND SLIP VELOCITY UNDER THE EURATOM PROGRAM. Quarterly Progress Report, April 15, 1963–June 30, 1963. (Allis-Chalmers Mfg. Co.

Atomic Energy Div., Milwaukee). July 10, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(11-1)-1272. 25p. (EURAEC-742)

Vapor volume fraction (void fraction) experiments using a gamma attenuation technique were planned. The experimental program required designing a test section and a steam generator. While the design of the test section was straightforward, the steam generator required considerably more attention because of the large flow and power requirements. Both designs were completed. All components of the gamma attenuation detection system were assembled and checked to be sure they were in proper operating condition. An IBM-1620 computer program was written to reduce the count rate data, taken during the experiments, to void fractions. A calibration of the void detection system was accomplished by scanning a Lucite-air mock-up of a water-steam flow pattern. The measured void fraction distribution was in good agreement with the known void distribution of the Lucite-air geometry. (auth)

**32242** (AE-113) AN ANALYSIS OF BURNOUT CONDITIONS FOR FLOW OF BOILING WATER IN VERTICAL ROUND DUCTS. Kurt M. Becker and Per Persson (Aktiebolaget Atomenergi, Stockholm). June 1963. 28p.

A method of predicting the burnout conditions for flow of boiling water in vertical round ducts is presented. The analysis predicts that the burnout conditions are independent of the L/d-ratio and the inlet temperature, and that the burnout steam quality decreases with increasing surface heat flux and increasing mass velocity. It was also found that the burnout steam quality at low pressures increases with the pressure and reaches a maximum at approximately 70 kg/cm$^2$, and thereafter decreases with a further increase of the pressure. The theoretical result compares very well with experimental data from different sources. (auth)

**32243** (AE-114) MEASUREMENTS OF BURNOUT CONDITIONS FOR FLOW OF BOILING WATER IN VERTICAL ROUND DUCTS. PART 2. Kurt M. Becker, Per Persson, Lars Nilsson, and Olle Eriksson (Aktiebolaget Atomenergi, Stockholm). June 1963. 29p.

The results of the second phase of an experimental investigation of burnout conditions for flow of boiling water in vertical round ducts are presented. Eight hundred and nine burnout measurements were obtained. The results are presented in diagrams, where for a certain geometry, the burnout steam qualities, $x_{BO}$, were plotted against the pressure with the surface heat flux as parameter. The data were correlated by curves, and the scatter around the curves is less than ±5%. In the ranges investigated, the observed steam quality at burnout, $x_{BO}$, generally decreased with increasing heat flux and mass velocity but increased with increasing pressure. The data were compared with the empirical correlation by Tong and excellent agreement was found for pressures higher than 10 kg/cm$^2$. (auth)

**32244** (EURAEC-637) CRITICAL HEAT FLUX DATA FOR FULLY DEVELOPED FLOW OF STEAM-WATER MIXTURES IN ROUND VERTICAL TUBES WITH AN INTERMEDIATE NON HEATED SECTION. Topical Report No. 5. A. Alessandrini, S. Bertoletti, G. P. Gaspari, C. Lombardi, G. Soldaini, and R. Zavattarelli (Centro Informazioni Studi Esperienze, Milan). Feb. 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract 060-61-7 RDI. 73p. (CISE-R-69)

Critical heat flux data obtained for fully developed flow of steam-water mixtures in round vertical tubes with an intermediate nonheated section are discussed. The use of the critical power (power applied to the test element at the instant of the onset of the crisis) and of the inlet quality for describing the crisis is discussed. The low quality instabilities (sharp reductions of the critical power) are shown to be in relation with near zero qualities obtaining in the non-heated portions of the circuit at the inlet or the outlet of the test element. (auth)

**32245** (EURAEC-671) CRITICAL HEAT FLUX DATA FOR FULLY DEVELOPED FLOW OF STEAM–WATER MIXTURES IN ROUND VERTICAL TUBES WITH NON UNIFORM AXIAL POWER DISTRIBUTION. Topical Report No. 7. S. Bertoletti, G. P. Gaspari, C. Lombardi, and R. Zavattarelli (Centro Informazioni Studi Esperienze, Milan). Apr. 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract 060-61-7 RDI. 30p. (CISE-R-74)

Critical heat-flux data were obtained for fully developed flow of steam–water mixtures in round vertical tubes with a nonuniform axial power distribution. The power distribution was either a linear function (decreasing or increasing) or a cosine function of the length along the test element. Comparison is made between uniform and nonuniform power distribution on the basis of the critical power and the inlet quality. Results on nonuniform power distributions have been translated into these same parameters. A conclusion is drawn on the validity of the rule of the critical power being independent of the power distribution. (auth)

**32246** (GEAP-4251) A PROGRAM OF TWO-PHASE FLOW INVESTIGATION. Quarterly Report No. 1, March–June 1963. F. W. Staub and N. Zuber (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). July 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 53p. (EURAEC-753)

The design and development of a heat transfer loop for studying two-phase flow are described. Facility engineering is about 75% complete. The condenser coolant circuit modification is complete. The major dimensions and characteristics of the metal and glass test sections are calculated. One feasibility test of the electrically conducting coating on samples of glass tubing is completed, and the second series of experiments has begun. The former dealt with refrigerant-coating compatibility during nucleate boiling and the latter with the photographic characteristics of the glass test section. The pressure and temperature transducer specifications are defined. The requirements for the x-ray instrumentation are considered, and the x-ray power supply is on hand. (N.W.R.)

**32247** (GEAP-4307) TRANSITION BOILING HEAT TRANSFER PROGRAM. Quarterly Progress Report No. 2, April–June 1963. E. P. Quinn (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). July 1, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 13p. (EURAEC-751)

Provision for accommodating transition boiling test sections was completed with the addition of a 125-kw d-c power supply and special piping to the General Electric Test Facility. Shakedown testing was carried out on a 2-rod cluster test section. The design and preparation of shop drawings for the fabrication of a new high-pressure observational test section are nearly completed. Development of optics, photography, and techniques to minimize fluid disturbances that can obscure viewing will be carried out on an atmospheric pressure loop that is presently being built. (auth)

**32248** (RCN-16) STRZ—A 7090 FORTRAN PROGRAM FOR THE STEADY-STATE TEMPERATURE DISTRIBUTION

IN R–Z GEOMETRY WITH TEMPERATURE AND DIRECTION DEPENDENT HEAT CONDUCTION COEFFICIENTS AND RADIATION IN NARROW GAPS. B. H. Boonstra, F. W. Hoff, and H. P. Struch (Reactor Centrum Nederland, Petten and IBM Netherlands, Amsterdam). 1963. 108p.

A 7090 FORTRAN program for the calculation of the steady-state, rotationally symmetric temperature field in an inhomogeneous cylindrical body, in which heat production, radiation in narrow gaps, and heat conduction with temperature and direction dependent conduction coefficients may occur. The body can be divided into at most 70 regions of constant heat production rate and consisting of one material composition. At most 35 material compositions with temperature-dependent heat conduction coefficients are allowed. Boundary conditions may be: constant temperature, isolation, or constant flow. At most 50 × 50 internal meshpoints are allowed. The numerical method is a two-level iteration process. (auth)

**32249** (SY-5455-R) THIRD QUARTERLY PROGRESS REPORT [ON MERCURY-LUBRICATED JOURNAL BEARINGS], OCTOBER–DECEMBER 1962. E. L. Wheeler and L. E. Chadbourne (Garrett Corp. AiResearch Mfg. Div. of Arizona, Phoenix). Jan. 20, 1963. For Atomics International, Div. of North American Aviation, Inc., Canoga Park, Calif. Contract N2S9-1630. 129p.

The effects of variables that are pertinent to the performance of mercury-lubricated journal bearings in the laminar and turbulent flow regions are analyzed. The effects of both bearing hydrodynamics and the rotor dynamics are evaluated so that the performance of mercury-lubricated bearings supporting a given rotating assembly may be predicted. The analysis is made using computer programs. (N.W.R.)

**32250** (TID-19224) AN EXPERIMENTAL INVESTIGATION OF BUBBLE MOTION IN TURBULENT LIQUID STREAM. Final Report-1. J. L. L. Baker and B. T. Chao (Illinois. Univ., Urbana. Engineering Experiment Station). June 1963. Contract AT(11-1)-1069. 124p. (ME-TN-1069-1)

The motion of single air bubbles in a water stream flowing turbulently in a 4" × 4" vertical conduit is investigated by photographic means. The bulk water velocity ranges from 40.8 to 267 cm/sec corresponding to a system Reynolds number range of 48,600 to 386,000. Both tap and demineralized water were used at room or near room temperatures. Air bubbles range from 0.038 to 0.80 cm in equivalent radius and the corresponding bubble Reynolds number based on relative velocity ranges from 58 to 4,500. Graphs showing the variation of bubble relative velocity with equivalent radius are presented for both the tap and demineralized water with the system Reynolds number as a parameter. The drag coefficient versus bubble Reynolds number plot is given and compared with that of a solid sphere and also with the air bubble data in calm water due to Haberman and Morton. In addition, the Weber number and the drag coefficient are plotted as a function of the Eötvös number. The variation of the aspect ratio of bubbles with equivalent radius is examined. The effect of the interaction between parent-satellite bubbles is discussed, and their motion is compared with that of single bubbles. An analysis of the optical effects with pertinent correction procedures is included in the Appendix in addition to an error estimation. (auth)

**32251** (TRG-Report 549) THEORETICAL INVESTIGATION INTO THE GENERATION OF ACOUSTIC NOISE BY NUCLEATE BOILING. J. Bree (United Kingdom Atomic Energy Authority. Reactor Group, Dounreay, Caithness, Scotland). May 8, 1963. 22p.

Warning of the onset of nucleate boiling in a liquid may be provided by the detection of the acoustic noise generated. This noise is characterised by its mean power spectrum, the theoretical determination of which was the purpose of the investigation described. The results of the theory are applied to nucleate boiling in water and in liquid sodium. (auth)

**32252** AN ANALYSIS OF SLUG FLOW HEAT TRANSFER IN AN ECCENTRIC ANNULUS. William T. Snyder (Brookhaven National Lab., Upton, N. Y.). A.I.Ch.E. (Am. Inst. Chem. Engrs.) J., 9: 503-6(July 1963). (BNL-6405)

A solution is presented for the temperature distribution in a fluid flowing in an eccentric annulus formed with circular cylinders under the assumption of slug flow. The flow is assumed to be fully developed thermally with constant thermophysical properties. The outer surface is assumed to be adiabatic and the inner surface temperature is assumed to be independent of circumferential position. General expressions and numerical results for a typical set of conditions are presented for the quantities, local heat flux, local heat transfer coefficient, adiabatic surface temperature distribution, and average Nusselt number. Application of the results to the prediction of turbulent heat transfer to liquid metals is indicated, and a comparison with other liquid metal heat transfer analyses is presented. (auth)

**32253** HEAT TRANSFER WITH LONGITUDINAL FLOW OF METALLIC SODIUM IN A TUBE BUNDLE. V. M. Borishanskii and E. V. Firsova. At. Energ. (USSR), 14: 584-5(June 1963). (In Russian)

The heat transfer characteristics of a stainless steel tube bundle having a staggered spacing of s/d = 1.2 were determined at temperatures of 210 to 310°C at sodium flow velocities of 0.16 to 2.02 m/sec. The oxygen content in the sodium was 0.017 wt %. The Prandtl number varied from 0.0057 to 0.0072, and the Reynolds and Peclet numbers were varied from 3.8 to 57 × $10^3$, and from 30 to 345 respectively. A plot of the Nusselt number versus the Peclet number showed that the experimental values lie below the theoretical curve. The two curves approached each other at Reynolds numbers of about 50 × $10^3$. At Reynolds numbers >$10^4$, the plot of Nu versus Pe for liquid sodium was in good agreement with the data of Friedland on liquid mercury. The data can be expressed by the following equation: $Nu = 6 + 0.006\ Pe$, where $Nu \equiv \alpha d_{hyd}/\lambda$, and $Pe \equiv \overline{w}\, d_{hyd}/a$. This formula can be recommended for calculating the heat flow for longitudinal flow of a liquid metal in a tube bundle with s/d = 1.2 to 1.75 with a staggered arrangement of tubes at $30 < Pe < 4000$, and $Re > 10^4$. (TTT)

**32254** HEAT TRANSFER BY MEANS OF ORGANIC LIQUIDS. G. C. Pinchera (CNEN, Rome). Energia Nucl. (Milan), 10: 319-35(June 1963). (In Italian)

The problems of stability, composition, and physical properties of polyphenyl coolants circulating in organic reactors are reviewed. Stress is laid on the importance that a more accurate knowledge of the composition and physical properties of such substances has for a better interpretation of the heat transfer data. The heat transfer characteristics of organic liquids are discussed. Recent experimental results on convective and boiling heat transfer and on critical heat flux were examined and compared with existing correlations. The effect of fouling on heat transfer was also considered. (auth)

**32255** HEAT TRANSFER IN ANNULAR PASSAGES—HYDRODYNAMICALLY DEVELOPED TURBULENT FLOW WITH ARBITRARILY PRESCRIBED HEAT FLUX. W. M.

Kays and E. Y. Leung (Stanford Univ., Calif.). Intern. J. Heat Mass Transfer, 6: 537-57(July 1963). (In English)

The problem of turbulent flow heat transfer in a concentric circular tube annulus with fully developed velocity profile and constant heat rate per unit of length is considered. Experimentally obtained solutions are presented for the thermal entry length for a fluid with Pr = 0.7. Asymptotic solutions (fully developed velocity and temperature profiles) are developed for a wide range of radius ratio, Reynolds number, and Prandtl number (Pr). The solutions are based on empirical velocity and eddy diffusivity profiles, and the validity of the solutions is demonstrated experimentally for Pr = 0.7. A superposition method is demonstrated for solving the problem of asymmetric heating from the two surfaces of an annulus, and experimental data on asymmetric heating are presented that are in agreement with the analysis. (auth)

**32256** FORCED CONVECTION IN A CHANNEL WITH WALL HEAT CAPACITY AND WITH WALL HEATING VARIABLE WITH AXIAL POSITION AND TIME. Robert Siegel (Lewis Research Center, Cleveland). Intern. J. Heat Mass Transfer, 6: 607-20(July 1963). (In English)

Heat transfer to a fluid with constant properties is analyzed for forced convection between two parallel plates. The plates have a finite heat capacity, and heat is supplied to them in an arbitrary manner with both time and axial position. The wall is assumed sufficiently thin or highly conducting so that the temperature variation through the wall thickness can be neglected. The fluid temperature is variable over the channel cross section, but the fluid velocity is assumed constant throughout the channel (slug-flow condition). The energy equation is laminar. A general method of solution is given and then some illustrative examples are carried out. These include uniform wall heating that varies sinusoidally in time, and heating varying sinusoidally with axial distance and exponentially in time. (auth)

**32257** HEAT TRANSFER BIBLIOGRAPHY. E. R. G. Eckert, E. M. Sparrow, W. E. Ibele, and R. J. Goldstein (Univ. of Minnesota, Minneapolis). Intern. J. Heat Mass Transfer, 6: 621-41(July 1963). (In English)

A bibliography is presented consisting of 716 references to material on heat transfer and fluid flow. (T.F.H.)

**32258** LAMINAR FREE CONVECTION IN CARBON DIOXIDE NEAR ITS CRITICAL POINT. H. A. Simon and E. R. G. Eckert (Univ. of Minnesota, Minneapolis). Intern. J. Heat Mass Transfer, 6: 681-90(Aug. 1963). (In English)

An experimental investigation on laminar free convection from a heated vertical flat plate immersed in carbon dioxide near its critical point is described. The test space was viewed with a Zehnder-Mach interferometer, thus giving an instantaneous picture of the distribution of refractive index. Use of the Lorenz-Lorentz equation and equilibrium property data enabled the temperature field to be inferred, permitting the calculation of the heat-transfer coefficient and the thermal conductivity of the fluid. Very low rates of heating were used, the temperature differences being of the order of 0.001 to 0.01°C, so that the constant property situation was closely approximated. High values of the thermal conductivity and the heat-transfer coefficient were detected in the critical region, both parameters showing a dependence on the heat rate. An engineering correlation for the heat-transfer coefficient was developed. The critical Grashof number for transition from laminar to turbulent flow was shown to be a function of the Prandtl number for the tests considered. (auth)

**32259** AN ANALYSIS OF THE CRITICAL HEAT FLUX IN NUCLEATE BOILING. J. M. Adams (Aerojet-General Corp., Sacramento, Calif.). New York, American Inst. of Chemical Engineers, (1963), Preprint 131, 12p. $0.50. (CONF-8-1)

From Fiftieth National Meeting, Buffalo, May 1963.

A three-dimensional stability analysis of a vapor jet is used to develop an equation for the critical heat flux. The critical heat flux corresponds to the maximum vapor velocity in the jet. In this analysis, the vapor velocity is related to the liquid and vapor properties by treating the jet as a cylindrical vortex sheet. (auth)

**32260** THE EFFECT OF CERTAIN GEOMETRICAL FACTORS ON DRYOUT FOR HIGH QUALITY STEAM/WATER MIXTURES FLOWING IN A VERTICAL INTERNALLY HEATED ANNULUS AT 1000 PSIA. J. G. Collier, G. A. Wikhammer, E. O. Moeck, and I. P. L. Macdonald (Atomic Energy of Canada Ltd., Chalk River, Ont.). New York, American Inst. of Chemical Engineers, 1963, Preprint Paper 37, 65p, $0.50. (CONF-129-2)

From Heat Transfer Conference, Boston, Aug. 1963.

Measurements have been made of the "dryout" heat flux (a term introduced to describe the "critical" or "burnout" heat flux for high steam qualities) for steam/water mixtures in the annular and dispersed flow patterns at 1000 psia. The test section consisted of an electrically heated element 0.6-in. OD having a length of either 19 in. or 29 in. located centrally inside a vertical 0.825-in. ID tube. Steam/water mixtures were formed by spraying water into slightly superheated steam. Experiments were carried out with various unheated cylindrical sections (0.6-in. OD and up to 40 in. long) attached to the upstream end of the heater. It was found that as the unheated section length was decreased so the dryout heat flux was reduced. With no unheated section ahead of the heater, dryout occurred at a low heat flux and simultaneously over the whole heater surface. It is assumed that a liquid film builds up on the unheated section, is transferred to the heated section by shear forces and is then thinned by evaporation and entrainment over the heated length. The one hundred and nine experimental data points have been correlated by this model with an rms deviation of 18%. (auth)

**32261** ON UNSTEADY HEAT TRANSFER OF COMBINED FREE AND FORCED CONVECTION IN CIRCULAR TUBES. L. N. Tao (Illinois Inst. of Tech., Chicago). New York, American Society of Mechanical Engineers, 1963, Preprint 63-APM-7, 6p. (CONF-6-3).

From Conference, Ithaca, N. Y., June 1963.

The unsteady heat-transfer problems of combined free and forced convection of a fully developed laminar flow of a heat-generating fluid in a circular tube with constant axial temperature gradient at the wall are investigated. The general solution with arbitrary time-dependent pressure gradient, heat generation, and wall temperature is established by the application of the "generalized Duhamel's theorem." Two specific cases are then studied. The results indicate that this type of transient problem has a time-variation of an oscillatory type with decaying amplitude. This time-variation is different from that of forced convection or of combined free and forced convection with constant axial wall temperature. (auth)

## Materials Testing

**32262** (HW-SA-2927) THE USE OF ULTRASONICS IN FATIGUE TESTING. Richard B. Socky (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Feb. 18, 1963. Contract AT(45-1)-1350. 42p. (CONF-112-1)

From National Convention on Nondestructive Testing, Los Angeles, Mar. 1963.

Methods used in ultrasonic testing are reviewed, and potentials for ultrasound as a nondestructive test for the correlation of material characteristics are discussed. The angle-beam theory is outlined. Applications of transverse wave, angle-beam techniques are demonstrated for an actual fatigue testing problem. (M.C.G.)

**32263** IMPROVEMENTS IN OR RELATING TO ULTRASONIC METHODS OF TESTING. Roy Samuel Sharpe and Sydney Aveyard (to United Kingdom Atomic Energy Authority). British Patent 930,687. July 10, 1963. Filed Oct. 25, 1960.

An ultrasonic method of testing the grain refinement in the outer annular region of a metal bar is patented. The method is especially applicable to measuring the grain size of U bars for use in reactor fuel elements. A pulsed ultrasonic beam is directed through the bar, with the transmitter and receiver mounted on either side of the bar on a chord displaced from the diameter. The bar, transmitter, and receiver are totally immersed in a suitable liquid, such as water. In the absence of the bar, the beam would be transmitted directly from transmitter to receiver. The attenuation of the pulses transmitted through the outer annular region of the bar is measured, the attenuation being proportional to the grain size. (M.P.G.)

# GEOLOGY, MINERALOGY, AND METEOROLOGY

**32264** (UCRL-10636) STUDIES IN TERRESTRIAL GAMMA RADIOACTIVITY. Harold A. Wollenberg and Alan R. Smith (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 12, 1963. Contract W-7405-eng-48. 63p. (CONF-136-1)

From Symposium on the National Environment, Houston, Texas, April 1963.

In a search for cement and aggregate materials low in radioactivity for low-background shielding concrete, substantial data were accumulated on the natural radiation environment. Methods used incorporate field measurement of the gamma radioactivity of various rock types by means of a portable scintillation counter utilizing a 3- by 3-in. NaI(Tl) crystal. Rock and soil samples were collected and, upon return to the laboratory, their gamma activities were studied with a 100-channel pulse-height analyzer (PHA). Mathematical techniques in the form of IBM-7090 computer codes were applied to the PHA data, yielding the concentrations of K, U, and Th in the analyzed samples; in addition, the contribution of fission-product fallout to each gamma spectrum was obtained. Correlation between field measurements and laboratory analyses are discussed; the serious complications to both posed by recent fallout are described. Results of K, U, and Th analyses are given for basaltic, ultramafic, carbonate, and quartziferous rock types. The results of a study of the radioactivities of portland-cement raw materials and finished products, and a possible correlation between the radioactivities of cements and their source limestones in the U. S. are discussed. A knowledge of K, U, and Th concentrations can be of great value to the earth scientist; proposed applications include determining the flow of heat in the earth's crust, establishing the temperature conditions at which rocks have undergone regional metamorphism, and determining possible correlations between the amount of K-feldspar and the concentrations of U and Th in Jurassic and Cretaceous sandstones in California. (auth)

**32265** STUDIES ON THE ABSOLUTE AGE OF URANIFEROUS MINERALS OF KATANGA AND NORTHERN RHODESIA. L. Cahen, P. Pasteels, D. Ledent, R. Bourguillot, L. van Wambeke, and P. Eberhardt. Ann. Musee Roy. Afrique Centrale, Ser. in 8°, Sci. Geol., No. 41, 53p. (1961). (EUR 43.f). (In French).

The position of the U mineralizations in the Katanga stratigraphical column is discussed. It is shown that the major phase of folding postdates all or nearly all the Katanga succession, the powerful thrusting of the Katanga belt postdates the major folding, and most of the U occurrences are younger than the thrusting or the folding and are thus posttectonic. The Rhodesian specimens available for study are described. The disseminated U mineralization of the specimens is shown to be epigenetic and posttectonic. This is confirmed by the geochronological results. Results of chemical and isotopic analysis are discussed. It is concluded that there are two distinct mineralizations dated at 620 ± 20 and 520 ± 20 m.y. Secondary pitchblende veins in N. Rhodesia are approximately dated at 365 ± 40 and 235 ± 35 m.y. (A.G.W.)

**32266** BIBLIOGRAPHY OF ABSOLUTE DATING MEASUREMENTS IN THE ANTARCTIC. A. Coppez and E. Picciotto (Université Libre, Brussels). Ann. Soc. Geol. Belg., Bull. 85: No. 8, 263-308(May 1962). (EUR 229.f). (In Italian)

A brief account is given of the radioactive dating methods and of their importance in Antarctic geology. A review is given of 15 articles dealing with age determinations on Antarctic rocks. One hundred and eighty determinations are compiled in a table giving the following information: location, rock sample, mineral analyzed, method, published age, and age recalculated with $\lambda_e$, $K^{40} = 5.85 \times 10^{-11}$ year$^{-1}$ and $\lambda_\beta$, $Rb^{87} = 1.47 \times 10^{-11}$ year$^{-1}$. All the data are also displayed on a map. The greatest part of the ages has been obtained by the A/K method on total rock. These ages represent probably the lower limits of the real ages. The youngest dated rock is the Gaussberg basalt (20 M.Y.). The dolerite dikes cutting the Beacon Series are about 180 M.Y. (Lower Jurassic). The oldest ages measured are of 1800 M.Y. The ages most widely distributed are grouped around 480 M.Y. (Ordovician). The magmatic and metamorphic features of most of the East Antarctic crystalline basement are consequently post-Cambrian. The geographical distribution of the absolute ages shows an "old" sector located between 70° Long. E and 150° Long. E, surrounded on each side by 500 M.Y. old rocks. (auth)

**32267** MICROBAROGRAPH RECORDINGS OF NUCLEAR EXPLOSIONS. Ferruccio Mosetti (Osservatorio Geofisico Sperimentale, Trieste, Italy). Atti, Ist. Veneto Sci., Lettere Arti, Classe Sci. Mat. Nat., 120: 59-65(1961-62). (In Italian)

The principles and operation of the microbarograph constructed two years ago are reported, and two recordings of Russian nuclear explosions at Nova Zemlja in October 1961 are presented. The pressure waves produced by nuclear explosions have a very characteristic shape that is clearly recorded by the microbarograph. A speed of 300 m/sec was found for those waves coming directly from the center of the explosion. It is suggested that microbarograph may be the best indicator of some nuclear explosions because of the unreliability of seismic recordings and of the indirect route of some air masses from the explosion center. (J.S.R.)

**32268** AGES OF PEGMATITE AND VEIN MINERALS FROM RWANDA AND BURUNDI. L. Cahen (Musée Royal de l'Afrique Centrale, Tervuren, Africa), R. Delwiche, and G. Monteyne-Poulaert. Bull. Soc. Belge Géol., Paléontol., Hydrol., 71: No. 2, 1-13(1962). (EUR 200.f). (In French)

Presented is part of a program dealing with the ages of pegmatite and vein minerals from the Kibara-Urundi-Karagwe Ankolean belt. Ages of sixteen pegmatite and vein minerals from Rwanda and Burundi were obtained by the strontium–rubidium ($\lambda = 1.47 \times 10^{-11}$ yr$^{-1}$), lead–uranium, and common lead methods. These ages fall into two groups. Eleven muscovites, one microcline, and one common lead, from tin and niobium–tantalum-bearing pegmatites and veins (8 localities in Rwanda and 3 in Burundi), yield apparent and conventional ages between 870 and 1,000 m.y. Three Sr–Rb determinations on lepidolites from similar pegmatites from Northern Katanga, comprised in the expression 920 ± 25 m.y., which lies in the range obtained in Rwanda and Burundi, are included for comparison. As the range from 870 to 1,000 m.y. is greater than the uncertainty of each measurement, it is probable that these pegmatites and veins do not represent one single event and

that part of the scatter is real. The age range 870 to 1,000 m.y. characterizes pegmatites and veins which are post-tectonic events of the Urundian or Karagwe-Ankolean cycle. The occurrences from Northern Katanga are post-tectonic events of the equivalent Kibara cycle. One, or two, much younger events are indicated by minerals found or thought to occur in quartz veins which are emplaced in the above-mentioned pegmatites. A mineral of the microlite-pyrochlore group from Buranga is circa 555 m.y. old and a galena from Kababara has a common lead conventional age of 620 ± 50 m.y. These figures occur in the range of Katangan and post-Katangan ages. The quartz veins therefore appear to be much younger than the host pegmatites. As this question is of interest to metallogeny it will be further investigated. A galena from Rushubi (Burundi) has a lead of anomalous isotopic constitution. (auth)

**32269** PRELIMINARY DATA ON THE ABSOLUTE AGE OF THE OLD FORMATIONS OF THE KASAI BASEMENT (SOUTHERN CONGO). J. Delhal (Fonds National de la Recherche Scientifique, Brussels), C. Lay, and D. Ledent. Bull. Soc. Belge Geol., Paléontol., Hydrol., 71: No. 2, 1-15 (May 1962). (EUR 199.f). (In French)

Ten Sr/Rb apparent ages obtained on minerals separated from rocks of the Kasai (South Congo) basement are interpreted as giving the age of three major events of the geological history of this basement. From North to South the area studied can be subdivised into three major portions: the Dibaya-type basement, the intermediate region, and the Luiza-type basement. A first metamorphism in the Luiza basement appears to be at least 3,300 m.y. old. It is followed by a charnockitization and a migmatitization. The latter phenomenon appears to be identical with the granitization of the Dibaya basement which occurred at circa 2,700 m.y. Later, an important cataclasis with pegmatitic intrusions affected the Dibaya basement. The pegmatites are dated at circa 2,100 m.y. This is also the age of the metamorphism and orogeny of the Luiza metasedimentary series which forms part of the intermediate region. This orogeny is therefore considered responsible for the above mentioned widespread cataclasis and activity. Three dated orogenic cycles are therefore superposed in this part of the Kasai basement; at least one younger, undated, cycle (the Lulua cycle) is recognized in the same general area. These preliminary results will be used as a foundation for a more complete dating program based not only on further Sr/Rb ages but also on ages obtained by other methods. An adequate nomenclature will be adopted as a result of the planned detailed studies. (auth)

**32270** COMPARATIVE STUDY OF AMPANGABEITES AND SAMARSKITES. L. Van Wambeke (Euratom, Ispra, Italy). Bull. Soc. Franc. Minéral. Crist., 83: 295-309 (1960). (EUR 40.f). (In French)

This study was done on various samples of ampangabeites and samarskites mostly by the combined x-ray diffraction-fluorescence method and also by differential thermal analyses. The x-ray fluorescence analysis was used for the determination of the chemical composition of these metamict minerals. The x-ray fluorescence pattern obtained on the inner zones was identical for both minerals, taking account of possible ionic replacement. For the weathered zone of these minerals, a pronounced lixiviation of Y and also U, Ca, and the other rare earths was observed often with an enrichment of Pb. The diffraction patterns taken after recrystallization were identical for the inner zones of ampangabeites and samarskites and also for the weathered zones. In the case of the inner zones especially, the fundamental structure of the pyrochlore-microlite-betafite series was found in the diffraction patterns with extra lines characteristic of samarskites. The differential thermal analysis shows for the inner and non-weathered zones of both minerals an exothermic peak at 710 to 715°C and for the weathered zones a peak between 670 and 685°C. For the weathered zones of ampangabeites of samarskites, a new chemical formula is proposed: $AB_{2+x}[O,(OH)]_{6+2.5x} nH_2O$, where A = TY, TCe, U, Ca, Fe, Th, Pb, and B = Nb, Ta, Ti, Sn. This formula takes account of the hydration and the lixiviation of some chemical elements. This study shows the identity of ampangabeite with samarskite. (auth)

**32271** EXPERIMENTAL DATA ON THE PULSE SHAPE INDUCED IN DRILL HOLES. A. M. Epinat'eva, V. V. Kuznetsov, Yu. A. Ostrovskii, and L. L. Khudzinskii. Izv. Akad. Nauk SSSR, Ser. Geofiz., No. 6, 861-75(June 1963). (In Russian)

Experimental data are given on the shape of seismic pulses produced by explosions in drill holes and on the elastic deformation. Close to the drill hole the shape varies with distance. At 0.75 km from the hole the shape becomes stationary. The short pulse and its half-period increase from the beginning to the end. Only a small elongation of waves with increased visual semi-periods was observed at 5 kw distance. (R.V.J.)

**32272** THE DEUTERIUM CONTENT OF RAINDROPS. Alfred H. Woodcock (Woods Hole Oceanographic Institution, Mass.) and Irving Friedman. J. Geophys. Res., 68: 4477-83(Aug. 1, 1963).

Raindrops are collected from within or near the bases of orographic shower-producing clouds in Hawaii as an exploratory effort to learn in what way, if any, the isotope concentration might be used as an indicator of the nature of the processes of drop growth in the trade-wind clouds. Much of the data reveal an inverse relation of deuterium and drop size. Alternative ways of explaining these data are briefly explored in terms of differences in the heights of the cloud tops, in the deuterium within them, and in the time required for drops to equilibrate as they fall through the clouds. It is concluded that the deuterium data given here are not useful as indicators of the processes of raindrop growth in Hawaiian orographic clouds. However, a study of these data, and of the relevant weather conditions obtaining when the raindrops are sampled, leads to specific suggestions for the altering of drop-sampling procedures so as to make measurements useful in testing certain models of raindrop growth. (auth)

**32273** THE VERTICAL DISTRIBUTION OF CESIUM 137 AND STRONTIUM 90 IN THE OCEANS. Gregory G. Rocco (Tracerlab, Waltham, Mass.) and Wallace S. Broecker. J. Geophys. Res., 68: 4501-12(Aug. 1, 1963).

Oceanic mixing rates derived from published measurements of $Cs^{137}$ and $Sr^{90}$ are at least a factor of 5 greater than those based on measurements of cosmic-ray produced $C^{14}$. In an attempt to resolve this anomaly, samples are obtained by the staff of the Columbia University research vessel Vema from which $Cs^{137}$, $Sr^{90}$, $C^{14}$, $Ra^{226}$, $H^3$, total Sr, total Cs, and total Ba can be determined. The techniques used for the $Cs^{137}$ and $Sr^{90}$ measurements are described and the results are presented for these two isotopes in profiles from the Caribbean, the eastern South Pacific, the Antarctic, and the North and South Atlantic oceans. No measurable amounts of $Cs^{137}$ or $Sr^{90}$ are found in the majority of samples taken below 300 meters. The observed distribution is more in keeping with that of natural radiocarbon. (auth)

**32274** CONCENTRATIONS OF COMMON LEAD IN SOME ATLANTIC AND MEDITERRANEAN WATERS AND IN SNOW. M. Tatsumoto (Geological Survey, Denver) and C. C. Patterson. Nature, 199: 350-2(July 27, 1963).

The concentrations of common Pb in the Atlantic Ocean and Mediterranean Sea were investigated. Samples of rural snow were also analyzed in attempts to validate the view that the oceans have been contaminated by lead tetraethyl aerosols. The concentration of 0.01 N HCl acid-soluble Pb in snow was about 2 μg Pb/kg snow. The isotopic composition of Pb from snow was found to be: $Pb^{206}/Pb^{204} = 18.01$; $Pb^{206}/Pb^{207} = 1.144$ and $Pb^{206}/Pb^{208} = 0.469$. The concentration of Pb measured in snow was found to be 10 to 100 times as large as that measured in sea water. In general, Pb concentrations at the Atlantic stations appear to increase from surface to intermediate or deep waters, and then decrease again in very deep or bottom waters. Common Pb concentrations in Central North Atlantic surface waters are about 0.05 μg/l. Values in offshore surface waters increase to 0.09 μg/l near Morocco and to 0.2 μg/l in the Mediterranean. (P.C.H.)

**32275** CAESIUM-137 IN AIR AND PRECIPITATION IN NORWAY DURING OCTOBER 1957. T. Hvinden and A. Lillegraven (Norwegian Defence Research Establishment, Kjeller). Nature, 199: 366-7(July 27, 1963).

Measurements were made of the $Cs^{137}$ content in ground-level air in Norway during Oct. 1957. The $Cs^{137}$ collected at Sola during Oct. 15 to 16 accounts for 62% of the mean value for Oct. The amount collected during Oct. 16 to 17 accounts for another 17%. The $Cs^{137}$ collected at Gardermoen during Oct. 16 to 17 accounts for 34% of the mean value for Oct. Data for the various towns are tabulated. (P.C.H.)

**32276** THE AMBIENT RADIOACTIVITY AND ITS ACTUAL INCREASE. J. L. Garsou (Université, Liege). Rev. Med. Liege, 15: 342-50(1960). (In French)

A resume is presented of the state of the ambient radioactivity, along with a bibliography of 56 entries. Natural and explosion-produced contributions to the total intensity are analyzed. The biological effects of the ambient activity are outlined. Meteorological effects of nuclear explosions are discussed. (T.F.H.)

**32277** SOME GEOLOGICAL PECULIARITIES AND PROSPECTION CRITERIONS OF HEIGHTENED CONCENTRATION AND DEPOSITS OF URANIUM IN COALS. A. A. Predovskii and G. G. Kochin. Vestn. Leningr. Univ., No. 6, Ser. Geol. i Geogr., No. 1, 36-45(1963). (In Russian)

Among uranium-bearing coals, paralic and limnetic formations may be picked out. The first variety is older. The second ones are usually mesocenozoic. Heightened concentrations and deposits of uranium in limnetic coals are mostly formed by means of infiltration addition. The origin of the deposits in limnetic coals is more complex. It is bound up with sedimentation, regressive epigenesis, and the late infiltration addition. For prospects it is important to take into account the position of the coal-bearing series in regional tectonic structures. Besides, the member of regional and local prospection criterions is connected with the peculiarities of the continental sedimentation and later hydrogeologic conditions. (auth)

**32278** RADIOGENNYI ARGON I MINERALAKH GORNYKH PORODAKH (Radiogenic Argon in Minerals and Rocks). Kh. I. Amirkhanov, S. B. Brandt, and E. N. Bartnitskii. Makhachkala, USSR, Publishing House of the Academy of Sciences, 1960. 202p.

A formal and physical theory on diffusion and sorption of argon is discussed, and technological procedures are suggested for estimating an absolute geological age of various minerals. (R.V.J.)

**32279** SPATIAL DISTRIBUTION AND TIME DECAY OF THE INTENSITIES OF GEOMAGNETICALLY TRAPPED ELECTRONS FROM THE HIGH ALTITUDE NUCLEAR BURST OF JULY 1962. J. A. Van Allen (Iowa State Univ., Iowa City). 40p. (CONF-77-3; SUI-63-11)

From Symposium on Plasma Space Science, Washington, D. C., June 1963.

Earlier observations with Injun I on the spatial distribution, absolute intensities and time decay of intensities of the fission decay electrons injected into the geomagnetic field by the high altitude nuclear burst of July 1962 are reviewed and put into more definitive form. The observations are extended to much later times after the burst by means of the new SUI/ONR satellite Injun III and by SUI equipment on the NASA satellite Explorer XIV. Total particle content of the artificial radiation belt at $\Delta t = 10$ hours is estimated at $1.3 \times 10^{25}$, or about 1% of the nominal yield of $\beta$ rays from the fission fragments resulting from the explosion. The radiation belt was eaten away markedly on the inner side and on the edges and to a lesser extent on the outer side during $5\frac{1}{2}$ months. At $\Delta t = 4050$ hours the particle content is estimated at about $2 \times 10^{24}$. The independent absolute measurements with Explorer XIV of electrons of energy greater than 230 kev give an omnidirectional intensity of $10^8$ $(cm^2\ sec)^{-1}$ at $\Delta t = 2800$ at the heart of the belt at $L = 1.3$, thus confirming the theoretical expectation of relatively more rapid loss of electrons of energy less than 1.5 Mev. The rate of decay of intensity is found to be a function of L but to be essentially independent of B, over a wide range of B, within a given magnetic shell. Preliminary comparison of the observations with the theoretical calculations of Walt show a striking level of agreement with the expectations of pure atmospheric scattering and energy loss. It is reasonable to expect a detectable residuum of the energetic electrons from the Starfish burst to persist for a decade at $L \sim 1.4$. These studies provide a significant advance in the understanding of the dynamics of geomagnetically trapped electrons in the region of the inner zone. (auth)

**32280** SOME PROPERTIES OF NATURAL RADIOACTIVITY IN THE ATMOSPHERE. M. Kawano (Nagoya Univ., Japan) and S. Nakatani. 32p. (CONF-16-9)

From International Symposium on the Natural Radiation Environment, Houston, Tex., Apr. 1963.

The concentration of radioactive substances was continuously measured by use of two ionization chambers; one for alpha, beta, and gamma radiations, and the other for beta, and gamma radiations. The difference between the ionization current measured by the two chambers is almost proportional to the concentration of the alpha emitters in the atmosphere. The ionization current was calibrated by use of a standard ionization chamber. The mean value of the maximum on each day was $6.5 \times 10^{-16}$ C/cc, and of the minimum was $1.2 \times 10^{-16}$ C/cc. The concentration of the radioactive dust was continuously measured by an electrostatic precipitator and a G-M counter. The maximum value for the radioactive dust carrying RaB and RaC was found to be 18 per cent, and the minimum was 6 per cent. Comparison of the diurnal variation curve of the concentration of the radioactive dust with that of radioactive substances revealed that the former curve was not parallel with the latter. The simultaneous measurements of these two elements were carried out in Tokyo for 12 months. To interpret the results of the simultaneous measurements, the constancy of the collecting efficiency of the electrostatic precipitator, the counting efficiency of the G-M counter

used for detecting the radioactivity trapped by the precipitator, and the influence of the presence of thoron and its daughter-products on the results of measurements of radon concentrations and its daughter-products are discussed. (auth)

**32281** SEASONAL VARIATIONS OF BOMB TRITIUM IN RAIN. G. Israel, W. Roether, and G. Schumann ([Universität, Heidelberg]). 7p. (CONF-55-1)

From Symposium on Trace Gases and Natural and Artificial Radioactivity in the Atmosphere, Utrecht, Aug. 1962.

The tritium activity of precipitation at Sindorf, near Cologne, Germany, has been monitored since 1960. Experimental results are presented and discussed briefly with the aid of a comparison to $Sr^{90}$ as another artificial nuclide characterized by similar tropospheric behavior. (auth)

# HEALTH AND SAFETY

*Refer also to abstract 33000.*

**32282** (AECL-1745) MANUAL OF LOW-ACTIVITY ENVIRONMENTAL ANALYSES. Procedures and Methods for Preparation and Radiochemical Analyses of Environmental Samples at AECL. J. E. Guthrie and W. E. Grummitt (Atomic Energy of Canada Ltd., Chalk River, Ont.). May 1963. 119p.

A series of analytical schemes for the measurement of $Ba^{140}$, $Sr^{89}$, $Sr^{90}$, $Cs^{137}$, $I^{131}$, and $Pu^{238}$ in various environmental materials is described. These procedures are based on radiochemical methods in use at Chalk River and have been thoroughly tested in practice. The manual is divided into distinct sections in the belief that such an arrangement will be a convenience where sample preparation, $\gamma$-spectrometry, radiochemistry, and counting are performed by different people working in separate areas of a laboratory. (auth)

**32283** (AEET/AM/34) ACTIVE PARTICLES IN FALLOUT FROM NUCLEAR WEAPON TESTS. K. G. Vohra, C. Rangarajan, and Kum. G. Sarada (India. Atomic Energy Establishment, Trombay). 1963. 9p.

During October 1961 some of the samples of air-dust collected on filter papers showed abnormally high beta and gamma activity. The observations on the identification of highly active particles of fallout matter at two of the sampling stations in India, i.e., at Nagpur and Bombay, on October 19 and October 30, 1961, are presented. The activities of the particles identified in the samples from Nagpur (October 19) and Bombay (October 30) were found to be 680 and 970 $\mu\mu c$, respectively. These particles showed 70 to 75% of activity due to fission product $Zr^{95}$ + $Nb^{95}$. Autoradiographs and the gamma spectra of these particles are presented. (auth)

**32284** (DPSPU-63-30-26B) RADIOIODINE RELEASE INCIDENT AT THE SAVANNAH RIVER PLANT. W. L. Marter (Du Pont de Nemours (E. I.) & Co. Savannah River Plant, Aiken, S. C.). May 1963. Contract AT(07-2)-1. 14p. (CONF-66-3)

From Symposium on the Biology of Radioiodine, Richland, Wash., June 1963.

A release of 153 curies of radioiodine from a Purex fuel processing facility, most of which occurred May 30 through June 3, 1961, temporarily increased the level of I-131 in the environment of the Savannah River Plant (SRP). Prevailing southwest winds and atmospheric inversions dispersed the radioiodine mainly to the northeast of the Plant. Theoretical dispersion equations proposed by Sutton and modified by Culkowski were verified by measurements of I-131 in air at distances up to 25 miles from the Plant. I-131 on vegetation decayed with an apparent half life of 5 days, as compared to the physical half life of 8 days. This is attributed to dilution of the activity by new vegetative growth. The reduction of radioiodine in milk closely followed the apparent half life in grass. Laboratory tests with iodine-contaminated vegetation showed that rainfall removed little or no iodine. Consumption of milk in the area of highest deposition could have resulted in a thyroid dose up to 1200 mrem for a child. Empirical relationships relating the transfer of radioiodine from air to grass and then to milk are compared with those determined earlier at SRP and elsewhere. (auth)

**32285** (DXRL-F8) FALLOUT IN NEW ZEALAND AND PACIFIC ISLAND TERRITORIES. Quarterly Report, January–March 1963. (New Zealand. Dominion X-Ray and Radium Lab., Christchurch). June 14, 1963. 16p.

Data are presented on total $\beta$ or $\gamma$ activity of air filters and samples of rain water collected in New Zealand during the first 3 months of 1963. Results are included from $Sr^{89}$ and $Sr^{90}$ measurements for rain water and $Sr^{90}$ measurements for milk and bone samples collected during the same period, and total $\beta$ activity of rain water and food samples. (C.H.)

**32286** (HW-76351) PROTECTIVE CLOTHING MONITORING SYSTEM. M. O. Rankin and W. G. Spear (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Mar. 1, 1963. Contract AT(45-1)-1350. 23p. (CONF-67-5)

From Health Physics Society Meeting, New York, June 1963.

An automatic conveyor-type laundry monitoring system, which monitors laboratory coats and coveralls simultaneously for both alpha and beta-gamma contamination, was developed to improve efficiency and monitoring control. The instrument employs eight alpha and seven beta-gamma scintillation large-area detectors, a garment conveyor, solid state circuitry, and appropriate signalling devices. In operation, garments are physically placed on hangers which are then placed onto the automatic loader. Each garment is then conveyed past the detectors where it is monitored for beta-gamma and alpha contamination. Contaminated garments are rejected and dropped into a special container if spot contamination exceeds 1000 d/m of alpha or 5000 d/m of mixed fission products. The acceptable garments pass through the system for folding and distribution. The system, which requires only one attendant, can effectively monitor 500 garments per standard shift. System operation has been fully successful for five months. (auth)

**32287** (LF-9) THE PARTICULATE STATE OF FISSION PRODUCTS RELEASED FROM IRRADIATED URANIUM WHEN HEATED IN AIR. I. PRELIMINARY RESULTS FOR $I^{131}$, $Te^{132}$, AND $Ru^{103}$. Technical Progress Report. John C. Gallimore and T. T. Mercer (Lovelace Foundation for Medical Education and Research, Albuquerque, N. Mex.). June 1963. Contract AT(29-2)-1013. 29p.

Experiments were carried out to study the particulate state of fission products released from irradiated uranium when heated in air. The effluent from the oxidation process was passed through a diffusion battery of four aluminum tubes followed by a membrane filter and activated charcoal trap. The diffusion tubes were cut into segments and analyzed by gamma spectrometry. The filters and charcoal traps were analyzed in a similar manner. From these data, diffusion coefficients were calculated, from which particle sizes could be estimated for $I^{131}$, $Te^{132}$, and $Ru^{103}$. $Ru^{103}$ appeared to be in an atomic form, while $Te^{132}$ was mostly in particles greater than 200 Å in diameter. There was no evidence of $I^{131}$ in the form of molecular iodine; instead, the majority of it appeared to be carried by particles having a bi-modal size distribution with peaks at about 15 and 60 Å. Approximately 10% seemed to be in the form of a gas or a vapor which would not adsorb on aluminum at room temperature. Less than 1.5% of the $I^{131}$ could have been on the same particles, or on particles of the same

size, as the $Te^{132}$. Uranium was found to be present in the effluent in particulate form, but it was not possible to tell whether it was there independently or in conjunction with the iodine or tellurium. (auth)

**32288** (NSEC-91) ANALYSIS AND EVALUATION OF FALLOUT RADIOACTIVITY IN PITTSBURGH PRECIPITATION. Status Report No. 3. R. C. Koch and C. R. Wilson (Nuclear Science and Engineering Corp., Pittsburgh). July 1963. Contract AT(30-1)-3072. 23p.

An investigation was made of selected radionuclides associated with debris from atmospheric nuclear detonations in precipitation samples collected at Pittsburgh, Pa. Data are presented on values for the monthly deposition rates and monthly mean concentrations of $Sr^{89}$, $Sr^{90}$, $Zr^{95}$, $Cs^{137}$, $Ce^{141}$, $Ce^{144}$, and Pu-$\alpha$ radioactivity in samples collected during the first 5 months of 1963. Data for individual precipitations are correlated with general meteorological parameters. (C.H.)

**32289** (SCPRI(RM)V-1963) RAPPORT D'ACTIVITE, MAI 1963. (Report of Activities, May 1963). (France. Service Central de Protection contre les Rayonnements Ionisants, Paris). 18p.

The results of the radiological monitoring of the atmosphere, nuclear sites, rain water, the food chain, and sea water are briefly summarized and shown graphically and in tabular form. (J.S.R.)

**32290** (TID-19111) THE MEASUREMENT OF ENVIRONMENTAL RADIATION. Annual Report. (New York Univ., New York. Graduate School of Arts and Sciences). June 15, 1963. Contract AT(30-1)-1704. 82p.

Progress is reported in the development and evaluation of radiation detection instruments for use in measurements of terrestrial and cosmic radiation backgrounds. Diurnal and seasonal variations in the cosmic ray background were investigated. Data are included from a study of low field strength operation of ionization chambers; columnar ionization in inert gases, such as argon and argon mixtures; and a spectral study of the low-energy electronic component of the environmental radiation at sea level. (C.H.)

**32291** (UCRL-7311) METHODS OF HANDLING AND LAUNDERING BERYLLIUM-CONTAMINATED GARMENTS. Jerry J. Cohen (California. Univ., Livermore. Lawrence Radiation Lab.). Apr. 8, 1963. Contract W-7405-eng-48. 26p. (CONF-84-1)

From American Industrial Health Conference, Cincinnati, May 1963.

In beryllium industries, it has been the general practice to supply workers with protective clothing. Problems in handling and laundering this clothing were investigated. These problems include: potential hazard to laundry workers and subsequent wearers of the clothing, special laundering techniques, methods to determine the degree of contamination on garments, and determining the most desirable types of garments for the purpose. Four methods to determine the degree of contamination discussed include the shake test, the vacuum test, the rinse test, and the smear test. Assuming conventional laundering procedures have been used, the potential hazard to subsequent wearers of the garment is minimal. Standards for determining adequacy of laundry are suggested. These are 0.1 $\mu$g Be/cm$^2$ as determined by the vacuum test, or 200 $\mu$g Be/garment as determined by the rinse test. Possible hazard to those handling contaminated garments could be significant. This hazard is best controlled simply by use of wet methods. Included in this report is the summary of a survey conducted to determine how these problems are handled in other beryllium industries. (auth)

**32292** (UR-629) A LABORATORY TEST CHAMBER FOR STUDYING AIR-BORNE MATERIALS. Leonard J. Leach (Rochester, N. Y. Univ. Atomic Energy Project). July 1, 1963. Contract W-7401-eng-49. 12p.

Construction details of a small (7-gallon) chamber for studying test atmospheres are presented. Chambers of this design were used successfully at Rochester for range finding toxicity tests, aerosol research, and educational purposes. The primary features are versatility, ease of maintenance, and simplicity. (auth)

**32293** (Y-1272) Y-12 PLANT NUCLEAR SAFETY HANDBOOK. J. W. Wachter, ed., M. L. Bailey, T. J. Cagle, W. T. Mee, R. H. Pletz, F. G. Welfare, and B. J. Youngblood, comps. (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). Mar. 27, 1963. Contract W-7405-eng-26. 190p.

Information needed to solve nuclear safety problems is condensed into a reference book for use by persons familiar with the field. Included are a glossary of terms; useful tables; nuclear constants; criticality calculations; basic nuclear safety limits; solution geometries and critical values; metal critical values; criticality values for intermediate, heterogeneous, and interacting systems; miscellaneous and related information; and report number, author, and subject indexes. (C.H.)

**32294** (CEA-tr-A-1221) DÉTERMINATION DE LA DOSE DES NEUTRONS RAPIDES A L'AIDE DE DÉTECTEURS À SEUIL. (Determination of Fast Neutron Dose by Means of Threshold Detectors). W. Koehler. Translated into French from German report FRM-42. 15p.

The use of threshold reactions (n,p) on $Ti^{46}$, $Ni^{58}$, and $Fe^{54}$, and (n,$\alpha$) on $Cu^{63}$ for neutron dosimetry in the Mev range is analyzed. Effects of side reactions and decays are discussed. (T.F.H.)

**32295** (JPRS-20511) INJURIES FROM ATOMIC BOMB EXPLOSIONS. A. A. Vishnevskii (Vishnevskiy) and M. I. Shrayber. Translated from p.45-58; 69-76; 122-5 of "Voyenno-Polevaya Khirurgiya," Moscow, 1962. 24p. (OTS-63-31464)

The management and treatment of injuries resulting from atomic bomb explosions are reviewed. (C.H.)

**32296** THE DESIGN AND CONSTRUCTION OF A NEW TYPE ISOTOPE STORAGE AREA. Charles A Hall and Booker T. Moore (Veterans Administration Hospital, Albany, N. Y.). Am. J. Roentgenol., Radium Therapy Nucl. Med., 90: 404-5(Aug. 1963).

The design and construction of an isotope storage area for a radioisotope laboratory are described. (C.H.)

**32297** GAMMA-ACTIVE FALLOUT NEAR TORONTO IN 1961-1962. V. K. Mohindra, J. E. Harrison, O. A. D. Trojan, and K. G. McNeill (Univ. of Toronto). Can. J. Phys., 41: 1281-6(Aug. 1963).

Results are given of measurements of the $Cs^{137}$ activity in the human body, milk, and air over a two-year period. They show that after a continuing decrease in activity since 1959, the levels of $Cs^{137}$ in the biosphere have taken a sharp rise since the fall of 1961. The latest figure for the $Cs^{137}$ burden in man is $10^{-2}$ $\mu$c, one three-thousandths of the occupational maximum permissible burden. (auth)

**32298** ON THE STRATOSPHERIC FALLOUT OF BOMB-PRODUCED CERIUM ISOTOPES. M. P. Menon, K. K. Menon, and P. K. Kuroda (Univ. of Arkansas, Fayette-

ville). J. Geophys. Res., 68: 4495-9(Aug. 1, 1963). (TID-18656)

A pronounced spring peak of the cerium fallout is observed in 1960 and also in 1961 in rain samples collected at Fayetteville, Arkansas. After the fall 1961 USSR test series, the $Ce^{144}$ concentration in rain increases sharply, whereas the $Ce^{141}/Ce^{144}$ ratio data indicate the absence of significant fractionation of these isotopes in the atmosphere. (auth)

**32299** THE RESULTS OF CALCULATION OF THE DOSE FIELD CREATED BY THE GAMMA-EMITTER AT THE BORDER OF TWO MEDIA. S. V. Nesterov (Research Inst. of Roentgen-Radiology, Ministry of Health, USSR). Med. Radiol., 8: No. 6, 80-1(June 1963). (In Russian)

A method for calculating dose fields with the aid of marginal problems for Helmholtz equation is presented. On the basis of the method, with the aid of a quick-action electronic computing machine, the isodose curves for a spot gamma source were obtained. (auth)

**32300** STRONTIUM-90 IN THE BONE OF DOMESTIC ANIMALS IN JAPAN OF 1957-1962. Noboru Miyao, Mitsuaki Hayashi, and Toshio Yonemura. Natl. Inst. Animal Health Quart., 3: 93-100(1963).

The total annual average of $Sr^{90}$ concentration in the bone of domestic animals in Japan from 1957 to 1962 was 4.0, 9.30, 8.79, 10.0, 10.3, and 17.4 $\mu\mu c$ per g of Ca in cattle and 11.8, 14.3, 25.1, 20.6, 21.9, and 30.8 in horses, respectively. The $Sr^{90}$ content in the horse bone was about twice as high as that in the cattle bone. A similar trend was observed on the Sr to Ca ratio of both bones. No effect of age was shown on the $Sr^{90}$ concentration of the bone neither in cattle nor in horses. From 1957 to 1959, small numbers of goat, pig, and bird bones were analyzed. The $Sr^{90}$ concentration in the goat bone, being 0.88 $\mu\mu c$ per g of Ca, was considerably lower than that in the cattle bone, being 4.0. The Sr to Ca ratio was about the same between them (0.37 and 0.31). This level was much lower in the pig bone (1.03 $\mu\mu c$) than in the cattle one (9.3 $\mu\mu c$). Both Sr to Ca ratio and $Sr^{90}$ level were much lower in the fowl and crane bones than in any other animal bone. This ratio was 0.12 in both bird bones. This level was 1.83 $\mu\mu c$ in the fowl bone in 1959 and 0.69 in the crane bone in 1958. The $Sr^{90}$ concentration of the bone appeared to be the highest in horses, the second highest in cattle, and the lowest in goats. (auth)

**32301** MEASUREMENT OF RADIONUCLIDES IN PEOPLE. Erich Oberhausen (Universität, Saarlandes, Homburg, Ger.). Naturw. Rundschau, 16: 262-5(July 1963). (In German)

A brief resume is given of the early history of the development of counters for the measurement of radionuclides in man. Then the characteristics of the modern whole-body counters, as first developed at Los Alamos and Argonne National Laboratory, are indicated. The advantages of NaI crystals over liquid scintillators as detectors in whole-body counters are discussed. The areas for the application of whole-body counters are indicated. (J.S.R.)

**32302** STUDIES ON FALL-OUT PARTICLES. [PART] III. Tetsuo Mamuro (Radiation Center of Osaka Prefecture); Akira Fujita, Takeyoshi Seiyama, Shogo Shirai, and Yukio Yamada. Nippon Genshiryoku Gakkaishi, 5: 491-7(June 1963). (In Japanese)

Electron microscopic examination and x-ray microanalysis of highly radioactive fallout particles were carried out, in order to examine their surface states in greater detail, and to investigate the chemical constituents of the nonradioactive carrier material in which are embedded fission products and induced radioactive elements. Electron microphotographs are presented of the particles whose mean diameters, $\beta$ activities, and fractionation factors for $Ce^{141} + Ce^{144}$ are tabulated. In these microphotographs, the surface state can be seen in greater detail than in the photographs taken through an optical microscope. It was revealed by the use of a scanning type electron probe x-ray microanalyzer that the main metallic components in a highly radioactive particle are iron and aluminum, and that a small amount of silicon is also present. The color of a highly radioactive particle under a microscope varies, for example, black, reddish or yellowish brown, golden, or colorless. On comparison of the spectra with each other, it was confirmed that the denser the color of a particle, the larger is the composition ratio of iron to aluminum. All the particles subject to examination were collected in the yard of the Radiation Center of Osaka Prefecture in the autumns of 1961 and 1962. (auth)

**32303** NEW DEVELOPMENTS IN THE DESIGN OF SHIPPING CASKS FOR IRRADIATED FUEL ELEMENTS. E. C. Lusk and J. E. Gates (Battelle Memorial Inst., Columbus, Ohio). Nucl. News, 6: No. 6, 11-14(June 1963).

Some aspects of designing casks for transporting irradiated fuel elements are reviewed. The major problems of shielding, heat removal, criticality, and economic considerations are treated along with some solutions to these problems. (R.E.U.)

**32304** NEW METHOD FOR ELIMINATING RADIOACTIVE CONTAMINATION. Przeglad Tech., No. 6, 2(Feb. 10, 1963).

It was confirmed that ultrasound can be used successfully to decontaminate surface areas contaminated with radioactive substances. Good results were obtained in tests under laboratory conditions. Ultrasound quickly and completely eliminated contamination from surface areas of glass, polyvinyl chloride, rubber, and Al. To deactivate surface areas of inorganic substances, an ultrasound generator with a frequency of 20 to 40 kc was used. To decontaminate surface areas of organic substances, an ultrasound generator used for therapeutic purposes can be used. (TCO)

**32305** CALORIMETRIC MEASUREMENTS OF ABSORBED DOSE FOR LOW- AND MEDIUM-KILOVOLTAGE X-RAYS. Paul N. Goodwin and Harry W. Adair (Johns Hopkins Hospital, Baltimore). Radiology, 81: 320-3(Aug. 1963).

It is shown that calorimetry is a simple and accurate method of measuring rads per roentgen in the conventional therapy range. Data are presented on primary beams that have half-value layers ranging from 0.2 mm copper to 4 mm copper. Measurement is made of rads per roentgen in bone at a depth of 2.5 cm from beams within the same quality range. (auth)

**32306** CAROTID COMPRESSION DEVICE FOR THE PREVENTION OF RADIATION HAZARD. Herbert Schunk. Radiology, 81: 324-6(Aug. 1963).

During a comprehensive investigation of cerebrovascular diseases with the aid of angiography, a considerable radiation dose to the hand of the examiner is inevitable. Because of this a device was developed and is described which prevents primary radiation injury to the hand while compressing the carotid artery. Application of the instrument is discussed. (H.M.G.)

**32307** EFFECTS OF THE FIRST RADIATION PROTECTION REGULATION ON PROCEDURES FOR WELD-

ING SEAM TESTING BY RADIOACTIVE RADIATION SOURCES. Rudolf Trumpfheller. Tech. Ueberwach., 3: 329-35(Sept. 1962). (In German)

Regulations are given for human protection against radiation in the x-ray testing of welding seams of steel tubes and containers, using $Ir^{192}$, $Cs^{137}$, $Sb^{124}$, and $Co^{60}$ as radiation sources, and the effect of the safety regulations on the mode of testing are discussed. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**32308** THE EFFECT OF X-RAYS AND SCATTERED RADIATION OF A DENTAL X-RAY UNIT. W. Michael. Thesis, Greifswald, Ger., Universität, 1961. 44p. $2.00.

The results of dose measurements in the vicinity of a dental x-ray machine are given. Based on these measurements, rules for the minimization of the doses to patients and personnel are discussed. (Gmelin Inst.)

**32309** RADIATION EXPOSURE TO MAN BY TELEVISION SETS AND LUMINOUS DIALS. K. Mueller. Thesis, Erfurt, Ger., Medizinische Akademie, 1962. 60p. $2.00.

Studies of radiation exposure of man by television sets and luminous dials indicate that exposure by these sources is no serious problem for the general population. Exposure of watch makers using luminous paints is discussed. (Gmelin Inst.)

**32310** TECHNIQUES FOR MEASURING RADIOACTIVE DUSTS. E. C. Hyatt (Los Alamos Scientific Lab., N. Mex.). [1962]. Contract [W-7405-eng-36]. 31p. (CONF-104-1) (LADC-5713). Preprint No. SM/41-32.

From IAEA Symposium on Radiological Health and Safety in Nuclear Materials, Mining and Milling, Vienna, Aug. 1963.

Basic air sampling techniques for evaluating the total radioactive dust concentration are described. These data are used to check on compliance with maximum-permissible-exposure levels, since these standards have a built-in particle size correction. However, since particle size and density are not determined, total dust concentration data do not correlate with clinical data. To achieve such correlation, the sampling techniques must be based on biological criteria. Two-stage air samplers were designed which distinguish between the fraction of inhaled dust deposited in the upper respiratory tract and that retained in the alveoli. The use of these air samplers in uranium mills indicated that the "respirable dust" is only a small per cent of the total airborne dust. (auth)

**32311** A RESPIRATOR PROGRAM FOR URANIUM MILLS. E. C. Hyatt (Los Alamos Scientific Lab., N. Mex.). [nd]. Contract [W-7405-eng-36]. 25p. (CONF-104-2) (LADC-5714). Preprint No. SM/41-33.

From IAEA Symposium on Radiological Health and Safety in Nuclear Materials, Mining and Milling, Vienna, Aug. 1963.

Radiation protection procedures for uranium mills are reviewed. The effectiveness of various types of air-purifying respirators is discussed and guides for upper limits of airborne contamination are presented. (C.H.)

**32312** FEASIBILITY STUDIES FOR THE ESTABLISHMENT OF PARAMETERS FOR BACKGROUND RADIATION MEASUREMENTS. Werner N. Grune, Joseph H. Mehaffey, Charles H. Kaplan, and Tom L. Erb (Georgia Inst. of Tech., Atlanta). 37p. (CONF-16-10)

From International Symposium on the Natural Radiation Environment, Houston, Tex., Apr. 1963.

A simple, reliable and reproducible field method for the analysis of radon-222 and radium-226 in water was developed. The procedures were applied to the analysis of ground waters during an extensive field sampling program in Maine and New Hampshire. To achieve significant results during a limited field survey it was desirable that the analytical procedures be as rapid as possible without loss of accuracy and that the equipment be compact and portable. A special field scintillation detection unit was assembled and is described. The feasibility of obtaining field measurements to estimate man's total exposure to background radiation was also studied. Initially it was necessary to establish parameters and techniques for radiation measurements in the environment. This research was designed to determine significant ratios between the major components of background radiation, viz., alpha, beta, and gamma radiations. To establish these ratios it was necessary to develop instrumentation of sufficient accuracy to determine the composition of natural background. Emphasis was placed on the development of a three-channel gamma analyzer. Radiation flux and air sample activity measurements were conducted utilizing the instrumentation developed under this study. (auth)

**32313** IODINE-131 IN BOVINE THYROIDS FOLLOWING ATMOSPHERIC FALLOUT FROM NUCLEAR TESTING (SEPT. 1961-JAN. 1962). W. Moore, P. D. Lambert, and W. A. Mills (Public Health Service, Montgomery, Ala.). 9p. (CONF-67-2)

From Health Physics Society Meeting, New York, June 1963.

A study was conducted during the period 21 September 1961–11 January 1962, to determine levels of $I^{131}$ activity in approximately 1300 thyroid glands excised from young calves pastured in the Montgomery, Alabama area. Approximately 26 glands were obtained daily on a five-day week schedule from a local abattoir. The maximum daily average activity that occurred during the study was 7,300 pc $I^{131}$/gm of thyroid, and the maximum activity of a single specimen was 17,800 pc/gm. Gross beta activity in air and $I^{131}$ values for milk and grass are reported and trends noted as to the time lapse for the occurrence of peak activities in the various types of samples. (auth)

**32314** A STUDY OF ENVIRONMENTAL EXPOSURE TO RADIUM IN DRINKING WATER. Larry D. Samuels (Public Health Service, Iowa City, Iowa). 17p. (CONF-16-12)

From International Symposium on the Natural Radiation Environment, Houston, Tex., Apr. 1963.

The population exposed to environmental radium is now the subject of intensive investigation by the Public Health Service, Division of Radiological Health. The Midwest Environmental Health Study has attacked the problem from several aspects: delineation of exposed group and investigation of hydrological variables influencing exposure, measurement of uptake of $Ra^{226}$ in persons consuming involved waters, analysis of factors affecting uptake of radium into the exposed population, and search for effects consequent to exposure to radium at the measured environmental levels. (auth)

**32315** A MANAGEMENT APPROACH TO REDUCING SHIPPER-RECEIVER DIFFERENCES. Edwin A. Wiggin. 10p. (CONF-80-2)

From Inst. of Nuclear Materials Management Meeting, Buffalo, June 1963.

As a result of a decision by the AEC's Pittsburgh Naval Reactors Operations to ship several batches of cold reactor fuel scrap to Oak Ridge rather than to commercial processing facilities, the Atomic Industrial Forum called a series of meetings to study shipper-receiver (SR) dif-

ferences. Out of the meetings came a dual set of procedures that can be used to advantage by both fabricators and processors in minimizing SR differences. In an effort to emphasize the dual responsibility, procedures were developed along as closely parallel lines as their respective operations would permit. Six additional precautionary steps that apply to both fabricator and processor were derived as a transition. Procedures issuing from the meetings were designed to be equally applicable to the handling of AEC contractor scrap and AEC licensed scrap. (H.M.G.)

**32316** ONE YEAR'S EXPERIENCE IN REGULATING BYPRODUCT, SOURCE, AND SPECIAL NUCLEAR MATERIAL IN THE COMMONWEALTH OF KENTUCKY. Charles L. Weaver (Kentucky State Department of Health, Frankfort). 10p. (CONF-67-9).

From Health Physics Society Meeting, New York, June 1963.

On March 26, 1962, Kentucky assumed regulatory control for the licensing of subcritical nuclear materials within its boundaries. The administration of the state radiological health program is described, and the manpower, fiscal, and equipment requirements are outlined. The licensing activity of the state is also described. Results are reported of preliminary studies of state-owned land for low-level radioactive waste disposal. The procedures for inspection of licensees are described. Proposed changes in the Radiological Health regulations of Kentucky in order to bring about compatibility with AEC's code of Federal Regulations are outlined. (D.L.C.)

**32317** A COMPARATIVE STUDY OF RADIATION REGULATIONS. G. Hoyt Whipple (Univ. of Michigan, Ann Arbor). 5p. (CONF-67-10)

From Health Physics Society Annual Meeting, New York, June 1963.

Discussion is presented on the questions: Is there a relation between safety regulations and accident rates? Is there a relation between safety regulations and rate of development? What margin for judgment should safety regulations allow? Answers to the questions were sought in a comparison between situations in the U. S. and in the United Kingdom, with particular emphasis on the regulation of radiation exposure by legislative means. (P.C.H.)

**32318** IMPROVEMENTS IN OR RELATING TO APPARATUS FOR REMOVING DUST FROM A BODY, SUITABLY A HUMAN BEING WEARING PROTECTIVE CLOTHING. Edward John Granger (to John Bass Ltd.). British Patent 930,800. July 10, 1963. Filed Mar. 21, 1961.

A patented apparatus for removing dust from a body consists of a chamber with a plurality of jet nozzles on the sides. The nozzles direct a downwardly inclined jet of air at the body to be cleaned, while a stream of air, under less pressure than that from the nozzles, is directed downward from the top of the chamber. The dust removed by the jets falls under the action of gravity and the air from the top of the chamber and is removed from the chamber. (M.P.G.)

# INDUSTRIAL APPLICATIONS OF ISOTOPES AND RADIATIONS

**32319** (AE-112) DETERMINATION OF THE ABSOLUTE DISINTEGRATION RATE OF $Cs^{137}$-SOURCES BY THE TRACER METHOD. S. Hellstroem and D. Brune (Aktiebolaget Atomenergi, Stockholm). July 1963. 17p.

$Cs^{137}$ sources were absolutely measured by the "tracer method," with $Br^{82}$ as a tracer nuclide and with application of the $4\pi\beta$-$\gamma$ coincidence technique. A self-absorption of 6% was found in sources obtained from a solution with a carrier-content of 400 $\mu$g/ml. The precision of the method for the determination of the $\beta$-emission rate was estimated to ±1%. The results were compared with those of other works. (auth)

**32320** (CONF-124-2) THE STATUS OF WORLDWIDE RADIOISOTOPE APPLICATION TO COAL. George J. Rotariu (Division of Isotopes Development, AEC). [1962]. 25p.

From Symposium on the Application of Advanced Technology to Coal Research, Lexington, Ky., June 1963.

The applications of radioisotopes in the coal industries by some of the major foreign world coal producers, including the USSR, are discussed. The areas of exploration, mining operations, process operations, storage, handling, transportation, mine safety, testing and analysis, and basic research are covered. (M.C.G.)

**32321** STUDIES OF A NEW METHOD OF LIQUID DENSITY MEASUREMENT USING NUCLEAR RADIATION. Hans Hart (Forschungsstelle für Technische Gasentladungen der DAW, Potsdam, Ger.). Chem. Tech. (Leipzig), 15: 354-7(June 1963). (In German)

Some traditional processes for continuous density measurements and their application limits are discussed. The principle of the floating density measurer is outlined. The optimum measurement arrangement using the floating method was determined. Diagrams and graphs are given. The immersion depth of the float is determined by the back-scattering of radiation, and the immersion depth depends on the density of the fluid. (M.C.G.)

**32322** RESULTS OF THE CANADIAN PILOT SCALE POTATO IRRADIATION PROGRAM. Food Irradiation, 3: No. 4, A2-15(Apr.-June 1963). (In English)

A potato irradiation program using a Mobile Cobalt-60 Irradiator was carried out in four provinces of Eastern Canada during the 1961-62 season in cooperation with twenty-six members of the potato industry. A total of 400 tons of potatoes was irradiated over a four months' period extending from October to February. Regular observations on both control and irradiated potatoes were conducted during storage by the Fruit and Vegetable Division of the Canada Department of Agriculture until final shipment to consumer markets or processing plants. The dose of 8,000 rads used in the program provided excellent control of sprouting in all storages regardless of variety, storage temperature, date of irradiation, method of storage or length of storage. When good material suitable for long term storage was irradiated and not mishandled during treatment, there was no effect on the rate of breakdown during storage. Irradiated potatoes were successfully processed into potato chips, instant mashed potato flakes, frozen french fries and pre-peeled fresh boilers. Irradiated potatoes were sold to Canadian consumers in the form of table stock and processed products. No complaints of any kind were received or reported regarding the acceptability of the irradiated potatoes. There was no unfavorable public reaction to the first irradiated food offered for sale in Canada. The results of the potato irradiation program have created a favorable climate for the future of potato irradiation in Canada. The operation of full scale irradiation facilities is envisaged within the next two years. (auth)

**32323** SOME EXPERIMENTAL DATA ON COBALT 60 RADIATION DOSES CAPABLE OF ARRESTING INSECT INFESTATION OF CEREALS AND FLOUR. P. Pesson (Institut National Agronomique, Paris). Food Irradiation, 3: No. 4, A18-21(Apr.-June 1963). (In English)

The effective minimum doses of irradiation vary from one species of insect to another: 10,000 rads for Calandra; a little in excess of 12,000 rads for Tribolium; 8,000 rads for the larvae of Tenebrio and for Gnathocerus; 12,000 rads for Rhyzopertha; 20,000 rads for Acanthoscelides obsoletus (bean weevil); and 16,000 rads for Ephestia kuhniella. Hence the general finding with regard to insect pests in stored grain is that 20,000 rads seem to be the minimum effective dose capable of arresting larval development or reproduction of all the species studied. (auth)

**32324** RECENT RESEARCH ON FOOD PRESERVATION BY IONIZING RADIATION IN GERMANY. U. Schutzsack (Federal Research Inst. for Food Preservation, Karlsruhe, Ger.). Food Irradiation, 3: No. 4, A22-5(Apr.-June 1963). (In English)

The development of food preservation by irradiation in Germany in recent years can be summarized by the statement that, after installation of the necessary radiation sources, work has been intensified in different disciplines. Concerning scientific research, detailed work on dosimetry with sources producing different kinds of rays has been performed. Moreover, chemical changes during irradiation, the resistance of microorganisms and their distribution within the foodstuffs have been studied. Technological investigations to find the best conditions for irradiation, with special attention to the application of pasteurizing doses, have been undertaken with foodstuffs of animal and plant origin. (auth)

**32325** THE ADAPTATION OF TRITIUM ($H^3$) SOURCES TO DEVICES FOR MEASURING VACUUM. D. Blanc and R. Dagnac (Faculté des Sciences, Toulouse). Vide, 18: 322-3(May-June 1963). (In French)

Severe difficulties were encountered with the radioactive sources used in gages of the "alphatron" type, so these were replaced by tritium sources. In a prototype, very simply constructed, the ionization current in air was proportional to the pressure between $10^{-3}$ and 50 torr, and varied from $10^{-12}$ to $10^{-3}$ amp. (auth)

**32326** WINTER RAIL–LUBRICANT STUDY. L. J. O'Riley, R. W. Tolmie, and A. B. Lillie (Atomic Energy of Canada Ltd., Ottawa). 19p. (CONF-82-4)

From Canadian Nuclear Association Conference on Heavy Water Reactors, Ottawa, May 1962.

During the past winter three sets of field tests were car-

ried out (December, January, February) on a railway to study the "carry" distance of various rail lubricants under winter conditions. Six different greases were studied. These were applied to the rail by track lubricators. The lubricants were tagged with the radioisotope phosphorus-32 and applied in the normal way. The amount of lubricant deposited on the rails was measured quantitatively with suitable instruments. (auth)

**32327** PROPERTIES AND USES OF A UNIQUE CERAMIC CARRIER FOR RADIOISOTOPES. T. N. Lahr and J. P. Ryan (Minnesota Mining and Mfg. Co., St. Paul). 7p. (CONF-17-5)

From Oak Ridge Radioisotopes Conference, Applications to Physical Science and Engineering, Gatlinburg, Tenn., Apr. 1963.

Ceramic microspheres for fixing radioisotopes were developed which are almost completely insoluble in water, sea water, and physiological fluids, easily prepared in high specific activities, and easily fabricated into sources. The physiochemical properties of the microspheres (brand name: 3M Radiating Microspheres) are described. Results are given of leaching tests, radiation effects on leaching behavior, and biological studies in rats. Some of the possible uses of the microspheres are described: beta gages, self-luminous sources, cancer therapy, alpha sources, etc. (D.L.C.)

**32328** THE USE OF RADIOACTIVE TRACERS IN PULP AND PAPER RESEARCH. D. W. Clayton (Pulp and Paper Research Inst., Montreal). 9p. (CONF-9-10)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Radioactive tracers used to follow the physical movements of various materials, such as wood chips, pulp fibers, and pulping or bleaching liquors, are usually short-lived isotopes and do not need to have the chemical identity of the material to be traced. Examples of tracers for these applications are $I^{131}$, $Ir^{194}$, $Cu^{64}$, $La^{140}$, $Na^{24}$, and $Rb^{86}$. Tracer applications in which the chemical identity of the traced material is retained as far as possible include studies of the penetration of Ca-base sulfite liquor into chips, sulfur exchange between lignin sulfonates and sulfite liquors, H exchange between cellulose and water, chemical reaction mechanisms of cellulose, and radioactivation analysis of phenyl mercuric acetate fungicide. Tracers used in this type of research include $Ca^{45}$, $S^{35}$, $H^3$, $C^{14}$, and $Hg^{203}$. Each tracer application is described briefly. (M.P.G.)

**32329** THE USE OF COBALT-60 FOR THE PRODUCTION OF INDUSTRIALLY IMPORTANT MATERIALS. Sharda DasGupta (Atomic Energy of Canada Ltd., Ottawa). 36p. (CONF-9-9)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Some recent developments in the production of new products by $\gamma$-induced reactions are outlined. The grafting of monomers of styrene and methyl methacrylate onto nylon and cotton fabrics and paper is described, including experimental procedures and the effects of radiation dose, monomer concentration, and dose rate. Improved physical properties, such as tensile strength, water resistance, crease recovery, and resistance to growth of microorganisms, were obtained. Cobalt-60 $\gamma$ rays are also used to develop grafted nylon moulding powders and radiation-resistant greases. Experiments are currently in progress to modify lignin by means of $\gamma$ radiation to produce a useful material. (M.P.G.)

**32330** SOME INDUSTRIAL APPLICATIONS OF NEUTRON ACTIVATION WITH A NEUTRON GENERATOR. H. P. Dibbs (Dept. of Mines and Technical Surveys, Ottawa). 14p. (CONF-9-8)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

An account is given of the general principles of neutron activation analysis and of the use of a positive-ion accelerator as a neutron source. Some examples of activation analysis with an accelerator are presented. (auth)

**32331** SOME USES OF RADIOISOTOPES IN AUTOMATION. E. W. Leaver (Electronic Associates Ltd., Willowdale, Ont.). 18p. (CONF-9-16)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

The properties of radioisotopes that make them especially useful for automation are summarized. Gamma-emitting isotopes are used in level gaging, and beta emitters are valuable for basis-weight gaging. The secondary radiation induced by radioisotopes has many applications in density and thickness gages and in light sources. Other applications of radioisotopes include sortation, proximity detection, and identification of vehicles. Limitations on the use of isotopes are discussed, including limits of accuracy and distance between source and detector, expense, and unreasonable public fear. (M.P.G.)

# INSTRUMENTS AND INSTRUMENTATION

## General and Miscellaneous

*Refer also to abstracts 32726 and 33389.*

**32332** (BNL-6878) A FLYING SPOT FILM MEASURING MACHINE EMPLOYING CROSSED GLASS FIBERS. R. B. Palmer (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 45p. (CONF-26-3)

From Optical Society of America Meeting, Jacksonville, Fla., Mar. 1963.

Flying-spot measuring machines for use on bubble chamber film were first proposed by P. V. C. Hough and B. W. Powell in 1960. A machine nearing completion at Brookhaven National Laboratory employs a fixed and moving fiber to generate a 15 μm spot that scans over an area 53 × 160 mm in 10 seconds. Centers of marks on the film are digitized to an accuracy of ± 5 μm and the coordinates fed on line into a computer for analysis. (auth)

**32333** (CONF-39-53) A DIFFERENTIAL CALORIMETER FOR RADIATION-INDUCED POWER. William Bradley Lewis (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). [nd]. Contract [AT(10-1)-205]. 16p.

From American Nuclear Society Meeting, Salt Lake City, June 1963.

The absorption of radiation by matter is of such a nature that measurements can separate the effects of two sources acting simultaneously. The principles of such measurements are discussed and used to design an instrument whose performance was tested in a pure gamma field. (auth)

**32334** (CONF-58-4) A LINEAR AMPLIFIER SUITABLE FOR HIGH COUNTING RATES. J. Hahn and V. Guiragossian (Columbia Univ., New York. Pegram Nuclear Physics Labs.). [nd]. 22p.

From IEEE International Convention, New York, March 1963.

A linear amplifier suitable for high counting rates is described. The amplifier uses double-delay-line-shaping to minimize base line shifts and to enable timing signals to be obtained from the zero crossover. Miniature delay lines are used and the amplifier is designed to work with lines as short as 100 nanoseconds. It has a maximum gain of 500 and a rise time of 18 nanoseconds. To minimize delay line reflections, the lines are terminated at both ends. A circuit is used to obtain the delay line shaping. The amplifier has good overload characteristics and is compactly constructed. It plugs into a frame designed to accommodate a series of compatible circuits of modular design. The front panel space required is 3.6 by 7 inches. Circuitry and performance are described. (auth)

**32335** (DESY-A2.99) UNTERSUCHUNGEN AN PHOTOMULTIPLIERN MIT OPTISCHEN IMPULSEN. (Study on Photomultipliers with Optical Impulses). J. Rathje (Deutsches Elektronen-Synchrotron, Hamburg). June 1963. 34p.

A test-apparatus was developed for measuring the characteristics of photomultipliers in the nanosecond range. With periodical light-pulses (½ nsec rise- and falltime, 2 nsec pulse width at half maximum) the spread of transit time with respect to the illumination point on the photocathode, the total transit time, the risetime of the output signal and the gain can be measured as a function of parameters like high voltage or electrode-voltages. The output pulses are displayed on a Tektronix Sampling oscilloscope, Type 661. Different photomultipliers can be tested, and it is possible to find out the most qualified photomultiplier for a specified application. As an example the measurements made with a Philips 56AVP are described. (auth)

**32336** (ISS-63/25) SERVIZIO ELETTRONICO—CATALOGO DELLE APPARECCHIATURE ELETTRONICHE STANDARDIZZATE DA E 121 A E 130. (Electronic Service— Circuit Diagrams and Characteristics of Standard Electronic Equipment E 121 to E 130). (Italy. Istituto Superiore di Sanità, Rome). Mar. 20, 1963. 39p.

Circuit diagrams and characteristics for some electronic devices built at the Laboratory of Physics are included. (auth)

**32337** (K-1577) ELECTRO-PNEUMATIC CONSTANT VOLUME MANOMETER. J. Farquharson (Oak Ridge Gaseous Diffusion Plant, Tenn.). Aug. 15, 1963. Contract W-7405-eng-26. 12p.

An electro-pneumatic instrument was developed to facilitate absolute pressure measurements up to one atmosphere correctly to ± 0.1 mm of Hg. The major features of this instrument, which made possible the automation of a system for the measurement of the surface area of solids, are described. The pneumatic components are commercially available. (auth)

**32338** (NP-12989) MICROMINIATURIZATION; ITS APPLICATION TO ELECTRONIC CIRCUITS AND COMPONENTS. An Annotated Bibliography. Jack B. Goldmann, comp. (Lockheed Missiles & Space Co., Sunnyvale, Calif.). June 1963. Contract AF04(647)-787. 59p. (SB-62-67)

References (139) and descriptions for articles in 1962 publications on thin films, micromodules, solid-state devices, dot circuits, and other related topics are included. Manufacturing development research and evaluation techniques are emphasized. An author index is provided. (D.C.W.)

**32339** (RT/EL(63)3) UN AMPLIFICATORE IN CONTINUA PER TERMOPILE A NEUTRONI O TERMOCOPPIE. (A Continuous Amplifier for a Neutron Thermopile or Thermocouple). S. Colussi, F. Fioroni, and R. Marconero (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratorio di Elettronica, Rome). Mar. 1963. 13p.

Design criteria and fundamental characteristics of a d-c amplifier with insulated input stage, 0.1 μv drifts per 24 hours, and a rejection factor higher than $10^6$ for common effect are described. This amplifier is particularly useful for high precision measures with neutron thermopile or thermocouple. (auth)

**32340** (TID-19170) TRANSISTORIZED DIGITAL RATEMETER: AN INSTRUMENT FOR FOLLOWING RAPID COUNTING RATE VARIATIONS. Paolo Franzini (Pisa, Italy. Universita. Centro di Medicina Nucleare). [nd]. Contract AT(30-1)-2648. 7p.

A ratemeter was developed, which has good characteristics of reliability, stability, and precision due to the use of transistor digital circuits. The instrument is essentially a binary scaler, having 15 transistor binaries, which count the input pulses. Periodically the information in the last 8 binaries is transferred to a memory constituted of 8 more

binaries and the scaler is reset to zero. Three types of circuits are used: saturated binary, saturated Nor, and univibrators. The scaler, transfer circuit, and memory can be checked with a built-in crystal oscillator. (M.C.G.)

**32341** (TID-19175) SIX METER FOCAL LENGTH EBERT-TYPE INFRARED SPECTROGRAPH. PART I. DETAILS OF THE SPECTROGRAPH. K. Narahari Rao and H. Nielsen. PART II. PRECISION OF MEASUREMENTS. K. Narahari Rao and Phillip E. Fraley (Ohio State Univ., Columbus). [1962]. Contract [AT(11-1)-882]. 32p.

A description is presented of a recently constructed Ebert-type vacuum infrared spectrograph. The grating employed is a 73.25 grooves per millimeter 10 × 5 in. ruled echelle blazed for an angle of 63° 26′. The entire instrument operates in a vacuum. Facilities are provided for use of the spectrograph with tritium-substituted compounds like $NT_3$, TF, $CT_4$, etc. A semi-empirical procedure for determining spectral positions to an accuracy of $\pm 0.005$ $cm^{-1}$ in the near infrared region is discussed. The infrared spectra were scanned by rotating the grating with the help of a precision screw. (auth)

**32342** (UCRL-10855) AN INSTABILITY IN THREE-PHASE MAGNETIC AMPLIFIER OPERATION (thesis). Leslie Terence Jackson (California. Univ., Berkeley. Lawrence Radiation Lab.). June 1963. Contract W-7405-eng-48. 58p.

Difference equations in Laplace Transform notation were derived to represent the incremental operation of the three-phase magnetic amplifier with parallel control windings. A time-constant expression, verified by measurements on a test amplifier, was obtained from the difference equation; and the inherent operating characteristics of the amplifiers were studied. An unstable region occurred just below half-maximum output due to the positive feedback from the output through the gating core to the resetting core becoming greater than unity. Methods for eliminating this regeneration are discussed. (auth)

**32343** (UCRL-10874) A MULTIPARAMETER PULSE-HEIGHT RECORDING SYSTEM. Michiyuki Nakamura and George S. Simonof (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 1963. Contract W-7405-eng-48. 10p. (CONF-103-1)

From Conference on Instrument Techniques in Nuclear Pulse Analysis, Monterey, Calif., Apr.–May 1963.

A multiparameter pulse-height recording system was built and has been in operation for approximately one year. The system was used principally in studies of nuclear fission. The system can record up to ten coincident parameters for each nuclear event. Stretchers are used to store the pulse amplitudes temporarily, and then serially read the stretchers into an ADC unit. The digitized pulse heights are stored in predetermined locations of a magnetic-core buffer store. The buffer store can handle 512 pulse heights before dumping periodically onto magnetic tape. Each parameter has 256 channels of resolution. The magnetic tape format is "IBM compatible," with a recording density of 200 characters per inch. It takes 80 msec to dump the buffer store information onto magnetic tape. This 80-msec interval limits the speed at which information can be recorded. The information on the tape can be read back into the magnetic-core store by selecting one of the parameters and obtaining a "singles" spectrum of that parameter. When it is thought that reasonable data are collected, the reel of magnetic tape is taken to an IBM 7090 computer for delayed analysis. (auth)

**32344** (AEC-tr-5901) GENERATION OF A PSEUDO-RANDOM GATING IMPULSE BY A LOGICAL SHIFT REGISTER WITH BINARY FEEDBACK. [T. E.] Stern, Cazemajou, B. Macherez, Valat, and A. Vignon [France. Commissariat à l'Énergie Atomique. Centre d'Études Nucléaires, Saclay]. Translated from a French report. 13p.

The theory and construction of a device for generating a pseudo-random gating impulse for modulating a neutron source used in measuring the reactivity (or other parameters) of a reactor are discussed. A logical shift register with flip-flops generates a periodic binary sequence that, under the proper restrictions, acts as the desired pulse. (D.C.W.)

**32345** MASS PEAKS FROM ADSORBED GASES IN A SINGLE-FOCUSING MASS SPECTROMETER. J. L. Robins (National Research Council, Ottawa). Can. J. Phys., 41: 1385-7(Aug. 1963). (NRC-7441)

During operation of a single-focusing mass spectrometer in the pressure range $10^{-8}$ to $10^{-10}$ torr, a number of anomalous peaks were observed in the spectra at non-integral mass numbers, the two most prominent being at positions corresponding to masses of about $16\frac{1}{3}$ and $19\frac{1}{4}$. Origins of the anomalous peaks are discussed. (L.T.W.)

**32346** ELECTRON BEAM TRAJECTORY TRACING BY CAUSTIC AND SHADOW IMAGE. Koichi Kanaya, Hisazo Kawakatsu, and Shigeo Matsui (Electrotechnical Lab., Tokyo). Denki Shikensho Iho, 26: 881-96(Dec. 1962). (In English)

Further considerations for caustic and shadow image patterns, which were utilized to measure the spherical and astigmatic aberrations of an electron lens, are developed as a method of electron beam trajectory tracing. If the image position is in the caustic region across the back focal point, a complicated pattern of shadow image combined with the caustic pattern called Lissajous-like pattern appears. According to the experiments for a long focal lens, it is ascertained that such pattern is in good accord with the theoretical calculation. The spherical and astigmatic aberrations as well as the caustic entrance plane, the disk of least confusion and current density, which are serious limiting factors in performance of high resolving electron microscope and fine electron beam instrument, are more precisely obtained by the method of electron beam trajectory tracing. (auth)

**32347** A TRANSISTORIZED NUCLEAR INSTRUMENTATION SYSTEM FOR NUCLEAR RESEARCH. C. E. L. Gingell (Yale Univ., New Haven). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 32-43(July 1963).

A brief description of the transistorized modular nuclear instrumentation developed for use at Yale is presented. The salient advantages of this system including greatly reduced space and power requirements, increased reliability, flexibility and convenience of use through a library of circuit elements and finally, ease of assembly of complex systems and of servicing are stressed. Emphasis is also placed on the importance of very close liaison between the instrument design and development engineer and the scientific users of the instrumentation. (auth)

**32348** THE UTILIZATION OF MULTIPARAMETER ANALYZERS IN NUCLEAR PHYSICS. Leon J. Lidofsky (Columbia Univ., New York). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 52-8(July 1963).

The role of multiparameter analyzers in nuclear experiments to increase the understanding of fundamental

phenomena is discussed and illustrated with several examples. (C.E.S.)

**32349** AN IMPROVED SOLID-STATE LOGARITHMIC AMPLIFIER. I. Izumi and M. Okano (Mitsubishi Atomic Power Industries, Inc., Omiya, Japan). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 82-90 (July 1963).

A logarithmic amplifier is described which is composed entirely of solid state components. Logarithmic characteristics can be improved by the compensation of low saturation current Si-diodes with an appropriate Ge-diode. By the use of reverse-biased Si-diode dielectric modulator as the input stage of the amplifier, an input resistance of $5 \times 10^{10}$ ohms and a signal threshold of $10^{-11}$ amp are obtained at room temperature. A range of 7 decades is covered, that is, from $5 \times 10^{-11}$ to $5 \times 10^{-4}$ amp, with the accuracy less than ±2% of a decade and the temperature drift less than ±0.005 dec/°C over a temperature range from 0 to 50°C. (auth)

**32350** PROGRESS AND RECENT PROBLEMS IN MASS SPECTROMETRY. Jacques Collin (Université, Liege). Ind. Chim. Belge, 28: 621-8(June 1963). (In French)

Among the recent developments in the field of mass spectrometry, special attention is given to apparatus with very high resolution power as well as to the high degree of precision and sensitivity of the isotopic analyses. The development of instruments is examined, along with the possibilities of using the technique in qualitative and quantitative analysis of solids and in titration of trace elements. Means for studying ionized states obtained by electrons or photons are examined. Recent applications are mentioned. (auth)

**32351** MAGNETIC TAPE RECORDING OF SCINTILLATION SCAN DATA. F. J. Bonte, J. S. Krohmer, and W. E. Romans (Univ. of Texas, Dallas). Intern. J. Appl. Radiation Isotopes, 14: 273-7(July 1963). (In English)

Necessary circuits were devised to convey all the information detected by a scanning scintillation probe to one channel of two-channel magnetic tape and to place upon the other channel information about the position of the scanning probe at all times. The data on these two channels may then be replayed at a rapid rate through a background erase circuit, at speeds up to 64 times recording speed. The image may be displayed upon the face of a memory grid oscilloscope tube. Various features of this circuit suggest that with it the maximum information can be extracted from stored radioisotope scan data. (auth)

**32352** THE USE OF XEROGRAPHY FOR AUTORADIOGRAPHY. H. E. Dobbs (Wantage Research Labs., Berks, Eng.). Intern. J. Appl. Radiation Isotopes, 14: 265-6(July 1963). (In English)

The possibility of using the xerographic process for autoradiography was examined. The results for a weak beta emitter (tritium) indicate that the exposure time required to produce a perceptible image is approximately the same as it is for a fast photographic plate. For longer exposures the xerographic image has a greater contrast. It is limited to locating fairly high levels of activity as prolonged exposures are prohibited due to the natural decay of charge from the xerographic plate. (auth)

**32353** A SIMPLE DEVICE FOR THE DETECTION OF SOLIDIFIED AIR ON COLD SURFACES. H. Meissner and W. Schilling (Technische Hochschule, Munich). Kerntechnik, 5: 252(June 1963). (In German)

The reflectivity of mirrors, which are fixed at the cold supply lines of a reactor cryostat, is used to detect the condensation of air, which has penetrated into the vacuum jacket of the cryostat. The reflectivity changes are observed by a simple photoelectric device. The detection of frozen air at reactor cryostats is very important because irradiation of solidified air generates a mixture of high explosivity. (auth)

**32354** ELECTRONIC MEASURING DEVICE FOR AVERAGE AMPLITUDE. H. Meister (Technische Hochschule, Munich). Nucl. Instr. Methods, 23: 57-60(May 1963). (In German)

An electronic device is described, with which the average amplitude of a pulse spectrum can be measured. As a practical example, the measurement of the average energy of the $\beta$ particles emitted by a radioactive source is demonstrated. (auth)

**32355** A PRECISION AUXILIARY BIAS UNIT. W. G. Gore, T. Ring, and C. H. Vincent (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). Nucl. Instr. Methods, 23: 69-73(May 1963). (In English)

A unit is described that will enable any 1 v portion of a pulse-height spectrum between 5 v and 55 v to be expanded to cover the range of a kicksorter. This may be used, for example, to observe the fine detail of the spectrum from a solid-state radiation detector. (auth)

**32356** LOW INPUT IMPEDANCE CURRENT INTEGRATOR. Ming-dou Tang (National Tsing Hua Univ., Taiwan, China). Nucl. Instr. Methods, 23: 104-8(May 1963). (In English)

The design and fabrication of a transistor current integrator are described. The circuit has very low input impedance—about 100 ohm, and is particularly suitable for measuring the beam current from the target of a Van de Graaff accelerator in which water cooling is employed. The operating range of the current integrator is 0 to 30 μa. Accuracy is about 0.5% in the range of 5 to 30 μa and about 3% in the range of 0 to 5 μa. (auth)

**32357** A CATHODE RAY TUBE FOR REFINING DIGITAL LENGTH MEASUREMENTS WITH OPTICAL GRATING FOR THE EVALUATION OF NUCLEAR EMULSIONS. G. Birkhoff (Kernforschungsanlage, Julich, Ger.) and L. Bondar. Nucl. Instr. Methods, 23: 122-4(May 1963). (In German)

A special cathode ray tube is described which, in connection with a moiré grating system, permits the digital read out in length measurements 10 times finer than with the usual technique. The maximal attainable accuracy and velocity of length measurement are given. The device is suitable for precise nuclear emulsion measurements. (auth)

**32358** A TRANSISTORIZED TIME-AMPLITUDE CONVERTER FOR SUB-NANOSECOND LIFETIME MEASUREMENTS. J. L. Rodda, J. E. Griffin, and M. G. Stewart (Ames Lab., Ames, Iowa). Nucl. Instr. Methods, 23: 137-40(May 1963). (In English)

A simple transistorized time-amplitude converter is described together with a cycling procedure which makes it possible to use centroid shift analysis to measure relative positron lifetimes with an accuracy of $\pm 3 \times 10^{-12}$ sec. (auth)

**32359** ON A FAST TRANSISTORIZED PULSE AMPLIFIER. A. Alberigi Quaranta and M. Martini (Università, Bologna). Nucl. Instr. Methods, 23: 169-70(May 1963). (In English)

A fast transistorized pulse amplifier was developed with a large dynamic range and a good frequency overloading.

Some of the amplifier characteristics are: voltage gain = 4.9, risetime = 3.5 nsec max, and output pulse maximum amplitude (linearly amplified on 125-ohm cable) = −12 v. The amplifier is extremely stable. (D.L.C.)

**32360** A MASS SPECTROMETER FOR STUDYING CHEMICAL REACTIONS. M. Barber, J. Cuthbert, J. Farren, and J. W. Linnett (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A, 274: 285-92(July 30, 1963).

A mass spectrometer designed to study gas-phase chemical kinetics is described. An ion source was constructed that incorporates a differentially pumped, electron beam filament chamber, and line-of-sight access from the sampling pinhole to the ionization region. Experiments that test the effectiveness of differential pumping in reducing contamination of the sample by pyrolysis products formed from the sample on the hot filament are described. (auth)

**32361** MASS SPECTROMETRIC SAMPLING THROUGH A SMALL HOLE IN THE ADIABATIC FLOW REGION. M. Barber, J. Farren, and J. W. Linnett (Oxford Univ.). Proc. Roy. Soc. (London), Ser. A, 274: 293-305(July 30, 1963).

A simple theoretical treatment of sampling by a mass spectrometer through a pinhole at pressures for which the mean free path of the molecules is small compared with the diameter of the hole is described. An expression that relates the ion beam intensity to the partial pressures of the components of a mixture on the high-pressure side of the sampling pinhole was derived. Experiments were carried out to test the validity of the theoretical expression; its applications to the analysis of chemically reacting and other systems were discussed. (auth)

**32362** APPLICATION OF THE MATRIX METHOD TO A BROWNE-BUECHNER SPECTROGRAPH. Roy P. Haddock (Univ. of California, Los Angeles). Rev. Sci. Instr., 34: 745-54(July 1963).

The motion of a group of ions (with respect to the trajectory of one of the ions) in a magnetic field of the form $B \sim r^n$ may be described by linear second-order differential equations when the displacement, slope, and momentum spread of the ions are small. The general solution may then be written as a matrix operating on the initial conditions. A procedure is described for interpreting the paraxial properties of a spectrometer system in terms of the matrix elements. Then it is shown that a similar treatment is applicable when the momentum spread is not small, as in the case of the Browne-Buechner spectrometer. The matrices for the Browne-Buechner spectrometer are derived and interpreted for a more general case than has heretofore been considered. (auth)

**32363** ENHANCEMENT OF SIGNAL-TO-NOISE RATIO BY CONTINUOUS AVERAGING: APPLICATION TO MAGNETIC RESONANCE. Melvin P. Klein and George W. Barton, Jr. (Univ. of California, Livermore). Rev. Sci. Instr., 34: 754-9(July 1963). (UCRL-6727(Rev.1))

Spectroscopic investigations commonly involve a measurement of power as a function of some external parameters. It is usual, for improvement of signal-to-noise, to modulate the interaction between the radiation and sample and to apply the resulting signal to a synchronous detector followed by an integrating filter and a chart recorder. An extended search for a weak signal may require slow scanning rates and long time constants. Such a combination imposes severe requirements on the stability of the equipment, for any nonstochastic noise can frustrate a single scan by exceeding the dynamic range of the chart recorder. An alternative approach to the problem is to accumulate many relatively rapid scans of the full spectrum so that the signals add coherently whereas the noise adds randomly. The first approach may be termed frequency domain filtering while the latter is termed time domain filtering. An example of the latter approach is reported employing a multichannel pulse-height analyzer as a storage device. The voltage from the output terminals of a spectrometer (nuclear magnetic resonance or electron paramagnetic resonance) is converted to pulses, the pulse rate being proportional to the voltage. The channels are opened successively in synchronism with the progress of the magnetic field. Thus each channel corresponds to a finite region of the field while the number of counts in each channel is proportional to the time integral of voltage corresponding to that field. In such an arrangement the signal increases directly as the number of scans while the noise increases as the square root of the number. In effect the average response is computed continuously. The great dynamic range, $10^6$ pulses/channel, precludes overloading or saturation effects. Since no long time constants are employed, low-frequency noise is no longer the limiting factor in equipment performance. Spectra are presented, resulting from many thousands of scans, which demonstrate that signal-to-noise ratios may be enhanced by one to two orders of magnitude without sacrifice of bandwidth. (auth)

**32364** NEW DOUBLE-BEAM FLUOROMETER. Milton Laikin (Beckman Instruments, Inc., Fullerton, Calif.). Rev. Sci. Instr., 34: 773-7(July 1963).

The design of a new double-beam fluorometer is described. This fluorometer uses a new double-beam lamp to alternately irradiate sample and reference. The resultant fluorescent light is detected by a photomultiplier. After amplification, the sample and reference signals are separated by means of a ring demodulator. The reference signal is fed back to the photomultiplier dynode supply and the sample signal to a meter which indicates the ratio of sample to reference. Ultimate sensitivity for quinine sulfate is 1 part per billion full scale. (auth)

**32365** LEVEL INDICATOR FOR LIQUID HELIUM. S. Meiboom and J. P. O'Brien (Bell Telephone Labs., Inc., Murray Hill, N. J.). Rev. Sci. Instr., 34: 811-12(July 1963).

A capacitor probe was developed for locating the level of liquid helium in a Dewar vessel. The problem of the very small difference in dielectric constant between liquid and gaseous helium is solved by complete guarding of the connecting cables and measuring probe except the capacitor. The capacitance meter is set at zero when the capacitor is above the liquid level. (D.L.C.)

**32366** MODIFIED BAYARD-ALPERT GAUGE WITH X-RAY SUPPRESSION. D. Lee (Univ. of Illinois, Urbana). Rev. Sci. Instr., 34: 816-17(July 1963).

A modified Bayard-Alpert inverted ionization gage was developed in which the effective x-ray limit is reduced by one or two orders of magnitude. In this modified gage, a second collector is added which is biased at typically 60 v below that of the first collector, and the collector currents are subtracted. The difference current corresponds to that of a gage with a sensitivity one-third of that of a standard gage, but with a greatly reduced x-ray current since the component x-ray currents nearly cancel. The critical parts of the modified gage are discussed. The gage should be useful in reading pressures in the $10^{-12}$ Torr region. (D.L.C.)

**32367** ORTHOGONAL COMPENSATORS OF INHOMOGENEITY OF MAGNETIC FIELD FOR NMR SPECTROMETER. V. V. Frolov and I. A. Kolihova. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 59-66(1963). (In Russian)

A system of orthogonal current compensators modeling spherical harmonics of magnetic fields is described. When used in a NMR spectrometer for intermediary magnetic fields, it allows improvement in resolution by an order; absolute resolution of 0.3 to 0.5 c/s in the volume of 15 $cm^3$ is achieved, $H_0$ = 17 gauss. The computation using spherical and cylindrical harmonics is described. (auth)

**32368** OPERATION AND CHARACTERISTICS OF NEUTRON DIFFRACTOMETERS. Wang-shou Ang, Huang-chio Chang, Tsi-len Yang, Tia-shen Chu, and Kuang-ting Li. Wu Li Hsueh Pao, 17: 222-9(May 1961). (In Chinese)

Experimental results on the operation characteristics and accuracy of the neutron diffractometer are presented. A NaCl monocrystal was used in the monochromator. The wave length of the monochromatic neutron beam was ~1.06 Å. The resolving power $\Delta\lambda/\lambda \approx 0.052$. The intensity of the neutron beam was $3 \times 10^6$ n/min. The diffraction diagrams of monocrystalline NaCl and a sample of $\alpha - Fe$ were presented. (tr-auth)

**32369** THE IMAGE-FORMING CHARACTERISTICS OF PERIODIC FIELD LENSES. Chien-pou Chen. Wu Li Hsueh Pao, 18: 514-26(Oct. 1962). (In Chinese)

A method to investigate the image-forming characteristics of periodic field lenses is proposed. Treating periodic field lens as a lens-element-combination, the expressions of its cardinal points can be obtained by using Ferrarias characteristic determinant. For a general case, with immersion lens as lens element, the expressions of cardinal points of periodic field lenses of three and five lens elements were given. In these expressions only cardinal parameters of lens element and geometrical parameters of electrode system are involved. These derived expressions are quite simple in form, easy for calculation with sufficient accuracy. Thus there is no difficulty in studying the general characteristics of these lenses. Using these expressions, the image-forming characteristics of some periodic field lenses with symmetrical two-tube lens of small gap-spacing as lens element were calculated and analyzed. (auth)

**32370** A STABILIZED ±20 kv POWER SUPPLY FOR AN ELECTROSTATIC ANALYZER. Shien-chieh Hsin and Yu-ching Lu. Wu Li Hsueh Pao, 18: 558-62(Nov. 1962). (In Chinese)

A stabilized high voltage power supply for an electrostatic analyzer is described. The design principle was analyzed in detail. The output voltage of this instrument may be varied continuously from ±5 to ±20 kv. Within this range the voltage stability is better than ±0.015% for about 3 hours. The ripple voltage is one part in 16,000. This instrument served normally for more than two years and was shown to be sufficiently simple and reliable both in operation and maintenance. (auth)

**32371** THE INVESTIGATION OF THE TIME RESOLUTION CHARACTERISTICS OF A PHOTOMULTIPLIER. Shou-min Wang (Hangchow Univ., China). Wu Li Hsueh Pao, 18: 600-4(Nov. 1962). (In Chinese)

A measurement for the time resolution limit produced by a photomultiplier, with the accuracy of $\pm 2 \sim 5 \times 10^{-9}$ sec, was made. With the aid of a hydrogen lamp, illuminating at $5 \sim 8 \times 10^{-6}$ sec, the flight time of photoelectrons of several kinds of photomultiplier was determined by employing the oscilloscopic method; an investigation as to the effect of the outer circuit of RCA-5819 for resolution time was made and the better working state suitable for instant observation for the spectrum excitation process was also determined. (auth)

**32372** BETA THICKNESS GAGE (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-811)

This package consists of 7 drawings and 1 photograph. The beta thickness gaging system provides dynamic measurement of all of the basic parameters in beta transmission and reflection gaging. The moving material consists of a rotating disc with provision for altering the thickness of a portion of the disc by stacking various numbers of layers. Four speeds of rotation are provided. A sealed beta source may be placed to transmit through the edge of the disc to the Geiger counter or may be placed along side the counter for backscattering measurements. The transistorized count rate meter provides a selection of different ranges appropriate to the type and thickness of the material under study. Using this gage system, thickness, duration of imperfection, speed, time constant, type of material, type of radioisotope, and statistical effects may be studied. (F.E.S.)

**32373** DENSITY AND LEVEL GAGING SYSTEM (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-813)

This package consists of 7 drawings and 1 photograph. The density and level gaging system consists of a plastic column to contain varying liquid levels and an electronic unit containing a high voltage supply, count rate meter, and pump controlling switch. A liquid is automatically pumped into the plastic cylinder from below causing the level of the liquid to rise. When the level passes between the source and the counter, located a little more than half way up the tube, the shielding provided by the liquid causes the count rate meter to decrease in intensity. This decrease triggers a preselected limit relay which shuts off the pump (and starts a timer) allowing the level of liquid to fall. (F.E.S.)

**32374** LOW-LEVEL BETA COUNTING TRAINING SYSTEM (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-814)

This package consists of 3 drawings and 1 photograph. The low-level beta system utilizes the multipurpose electronics unit with the shield and counter unit. Background radiation is reduced by massive shielding and anticoincidence cancellation. The anticoincidence or guard counter is a flat multiple anode sandwich counter. Several different types of simple geiger counters are provided. The system is used for natural radiocarbon dating, high dilution isotope tracer studies, and fallout measurement. (F.E.S.)

**32375** RADON MONITORING (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-815)

This package consists of 2 drawings and 1 photograph. The health-physics monitor for natural radon includes a photomultiplier, radon counter, multi-purpose electronics unit, and preamplifier unit. It is used with the liquid scintillation training system. The radon counter is a 100 ml cell with filling stopcock above the scintillation window below. The walls of the cell are coated with silver-activated zinc sulfide. The inner surface of the trans-

parent window must be electrically conducting to prevent spurious electrostatic effects. This is accomplished by the use of a stannic oxide film. The sensitivity in air to natural radon is approximately 5 counts per min per $10^{-12}$ curies with a background less than 0.3 C/m. The natural levels of radon are usually sufficiently high to count directly. (F.E.S.)

**32376** TRACER LEAK DETECTION TRAINING SYSTEM (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-816)

This package consists of 2 drawings. This system consists of a bell jar which can be evacuated, a capillary leak tube, a solution of a small, license-exempt quantity of radium chloride, and the apparatus in the radon monitoring system. The radon concentration in the bell jar and its escape may be monitored by using this system. Inserting the capillary leak tube between the bell jar and the radon counter, and varying the pressure on the clamp allows measurement of the radon leakage through the capillary leak tube. (F.E.S.)

**32377** GAMMA-RAY SPECTROMETER (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-817)

Seven drawings are presented of a gamma spectrometer used to study gamma spectra of exempt quantities of gamma-emitting isotopes. The system utilizes a simple, single channel, transistorized, pulse height analyzer; a sodium iodide crystal mounted on a photomultiplier tube; an amplifier; a standard high voltage power supply; and count rate meter. The system can also operate with a scaler in place of the count rate meter. (F.E.S.)

**32378** SOLID STATE ALPHA DETECTOR (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-818)

This package consists of 4 drawings. The solid-state detector for alpha particles employs a gold–silicon surface-barrier counter located on top of a small plastic box. It is used with an amplifier, oscilloscope, regulated power supply or batteries, and a pulse height analyzer. By using this system, various alpha particle groups from small exempt quantities of alpha emitters may be studied. (F.E.S.)

**32379** TRACER FLOW RATE SYSTEM (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-819)

This package consists of 9 drawings and 2 photographs. The system is used to demonstrate the applications of radioisotopes to flow rate measurements. Flow rate of liquids is measured by injecting radioisotope tracers at one point and detecting the passage of the radioactivity at a point down the line. The system alloys measurements of flow rate by both the differential and integral methods. The system includes a water filled vertical tube with a sealed exempt quantity of $Cs^{137}$ source floating on the surface. The level of the liquid is allowed to drop at any one of 7 flow rates. Three Geiger counters are set along the tube. Using the differential method the top and bottom counters operate as a count rate meter using the peak timing for the flow rate. In the integral method, the center counter is operated. The number of counts accumulated during passage of the tracer at the interface are recorded. This value is corrected for the background rate and by referring to static calibrations, the flow rate is calculated. Flow rate of crude oil in pipe lines is measured by this method. (F.E.S.)

**32380** TRACER WEAR SYSTEM (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-820)

This package consists of 3 drawings and 2 photographs. The tracer wear system is used to study the wear of materials, especially metals. The system is used to study the phenomenon of fretting corrosion produced on piston rings in automobile engines. Early corrosion may be followed by radioactive tracers and later the material transferred may be determined by weighing. An electric motor of 1,725 rpm and 115 to 130 v operates an eccentric which provides very fast horizontal motion of small amplitude. A long arm supporting the tip with the weights on it allows a study to be made of the rate of fretting under different pressures. (F.E.S.)

**32381** GAS CHROMATOGRAPHY AND RADIOTRACER SYSTEM (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-821)

This package consists of 10 drawings and 1 photograph. The gas chromatography and radiotracer system consists of a vapor-liquid chromatograph with a $C^{14}$ and tritium ionization chamber. It is used in the separation of difficult to separate substances and simultaneously measures the amount of radioactivity in each component. (F.E.S.)

**32382** CARBON-HYDROGEN ANALYZER (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-822)

This package consists of 10 drawings and 1 photograph. The carbon-hydrogen analyzer system utilizes the absorption of beta particles, in conjunction with measured density, to give the ratio of carbon-to-hydrogen in a hydrocarbon sample. The system consists of a simple chamber and a sample can. The can is located between a sealed beta source and an ionization chamber. The source is a 100 micro curie $Sr^{90}$ source sealed in a flat container not to exceed $^{13}/_{16}$ in. in dia mounted in a $^{1}/_{2}$ in. thick steel 3 × 3 × 2.25 in. holder. The ionization chamber is 2.50 in. long with a 1.25 in. OD and 1.12 in. ID, mounted on a plate $^{3}/_{16}$ in. thick and 2.50 in. in dia. The terminal is 2 Stupahoff bulbs type 95,2031 or equivalent. The electronics unit includes an electrometer, bridge, and feedback current amplifier. (F.E.S.)

**32383** COBALT 60 CHEMICAL IRRADIATOR FOR CLASSROOMS (CCC) (Engineering Materials). (Johnston (William H.) Labs., Inc., Baltimore and Division of Isotopes Development, AEC). (CAPE-888)

This package consists of 5 drawings. The irradiator is used for low level, integrated dose and dose rate studies and is designed for classroom use. It is used principally for chemical experiments in the irradiation of chemical materials, organic polymers, and pre-irradiated chemicals to obtain faster reactions. The body is made of $^{1}/_{4}$-in. thick leaded material. The irradiator was designed to be used with a 25-C $Co^{60}$ source. (F.E.S.)

**32384** ABSOLUTE CALIBRATION OF GAS CHROMATOGRAPHIC APPARATUS FROM ION CHAMBER MEASUREMENTS. D. C. Nelson and D. L. Paull (Applied Physics Corp., Monrovia, Calif.). 22p. (CONF-74-8)

From Conference on Mass Spectrometry and Allied Topics, San Francisco, May 1963.

When an ion chamber is connected in series with any gas chromatograph a given amount of radioactivity in a fraction results in the same ion-chamber signal regardless of the molecule to which the unstable isotope is attached. The effect of various peak shapes on this signal is treated theoretically and compared to experimental re-

sults. A simple generalized method using a radioactive "spike" is proposed by which better than one percent overall accuracy can be attained, independent of column, mass detector, and other operating conditions. (auth)

**32385** THE ORBITRON. B. G. Herb. 21p. (CONF-46-61)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

An ion gage that does not have deleterious effects on the vacuum system being studied consists of a cylinder with a rod at a positive potential (insulated from the cylinder) passing through its axis. Electrons injected at sufficiently high momentum (from a shielded W filament at one end of the cylinder and off its axis) move in orbits around the rod. Reflectors can be provided at the cylinder ends to hold the electrons in the cylinder. The gage has low power consumption and gives electron orbits up to 1000 cm or better. (D.C.W.)

**32386** A LIQUID DENSITOMETER WITH IMPROVED SENSITIVITY EMPLOYING X-RAY TRANSMISSION TECHNIQUES. J. A. Reuscher (Agricultural and Mechanical Coll., College Station, Tex.). 21p. (CONF-17-1)

From Oak Ridge Radioisotope Conference, Applications to Physical Science and Engineering, Gatlinburg, Tenn., Apr. 1963.

The feasibility of a highly accurate liquid densitometer using the transmission of low energy x rays was investigated. Radioactive Iron-55 was used as the source of x rays with a scintillation counting system as the radiation detector. The device was found to be highly sensitive to density changes of water in the sixth significant figure. Also concentrations of metal ions in a water solution were detected to the seventh significant figure. Even though the desired accuracy of ±0.00002 g/cc was not achieved, the feasibility of developing a liquid densitometer with this high accuracy was demonstrated. (auth)

**32387** A METHOD FOR THE DETERMINATION OF ION SOURCE PRESSURES IN MASS SPECTROMETERS OPERATED AT VERY HIGH PRESSURES. F. H. Field and M. S. B. Munson (Humble Oil and Refining Co., Baytown, Tex.). 8p. (CONF-74-6).

From Conference on Mass Spectrometry and Allied Topics, San Francisco, May 1963.

Studies involving operation of mass spectrometers at very high ionization chamber pressures up to 0.3 to 0.5 Torr have been made to observe the ion-molecule reactions occurring, and it is oftentimes desirable to determine the rates at which various reactions proceed. To obtain accurate rate constants it is necessary to know accurately the pressures existing in the ionization chamber of the mass spectrometer. A method is described for determining mass spectrometer ionization chamber pressures in the range 0.010 to 0.400 Torr, and results are presented on the flow behavior of gases entering the ionization chamber of the mass spectrometer. (D.L.C.)

**32388** A MAGNETOHYDRODYNAMIC FLOW ANGLE INDICATOR. A. E. Fuhs and O. L. Gibb (U. S. Air Force, Norton Air Force Base, Calif.). 19p. (CONF-24-4; BSD-TDR-62-318)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

By using the directional sensitivity of the electrical conductivity instrument, it is possible to measure the direction of the flow of a conducting gas. If only one coil set is used, a complex calibration procedure is necessary: however, by using two coil sets, the flow angle becomes a function only of the ratio of two signals. It is shown theoretically, and verified experimentally, that the signal varies as the cosine of the flow angle. The flow angle can be expressed analytically as a function of signal ratio. Calculated and observed signal ratios are in agreement. The precision of measurement is ±(1 deg. + 5%) for flow angles of +45 to −45 degrees. (auth)

**32389** ION SOURCE FOR SOLID MATERIALS. Helmut J. Liebl and Richard F. K. Herzog (Geophysics Corp. of America, Bedford, Mass.). 12p. (CONF-74-1).

From Conference on Mass Spectrometry and Allied Topics, San Francisco, May 1963.

An ion source based on the sputtering phenomenon was designed for the mass spectrometric analysis of solid samples. In this source, an arc discharge is maintained in an argon atmosphere in the duoplasmatron, and the resulting argon ions are extracted and focused on the target which is mounted on a rotatable disc. The secondary ions are then accelerated and focused onto the mass spectrometer slit. Secondary ion currents of the order of $10^{-8}$ to $10^{-10}$ amp are produced, depending on the sample material. Secondary ion spectra are given for Zn, rocks, and 304 stainless steel, and the last spectrum is discussed with respect to possible quantitative analysis. (D.L.C.)

**32390** MEASUREMENT OF DYNAMIC NUCLEUS POLARIZATION IN VERY WEAK MAGNETIC FIELDS USING A SPECIAL MODULATION METHOD FOR MAGNETIC RESONANCE SPECTROSCOPY. P. Parikh. Thesis, Mainz, Universität, 1961. 86p. $2.00.

The construction of a magnetic double resonance spectrometer for weak magnetic fields is described. With this instrument resonance lines can be measured with or without simultaneous excitation of electron resonances. The increase of proton resonance by dynamic polarization can be observed directly. The high sensitivity that is needed for weak magnetic fields was obtained with a side-band modulation technique. The dynamic polarization of solutions of the free radical $K_2(SO_3)_2NO$ in magnetic fields between 0.5 and 5 oersteds is studied. The Overhauser-effect was measured in various oil samples for 20 oersteds. The results are discussed in detail. (Gmelin Inst.)

**32391** METHOD AND APPARATUS FOR DETERMINING VAPOUR PRESSURES. Geoffrey Hairsine Bell and Aleksander Jerzy Groszek (to British Petroleum Co., Ltd.). British Patent 930,744. July 10, 1963. Filed Jan. 22, 1962.

A method and apparatus for determining vapor pressures below 0.1 mm Hg of organic substances are patented. The apparatus consists of a sample chamber, which can be maintained at a predetermined temperature, a device for blowing a stream of inert gas of the same temperature through the sample chamber, and a flame ionization detector for measuring the quantity of vapor contained in the effluent gas. The vapor content is determined by mixing the effluent gas with H, burning the mixture in air, and measuring the conductivity of the flame. The conductivity is proportional to the number of C atoms in the flame and is therefore a function of the C content and vapor pressure of the sample. (M.P.G.)

**32392** IMPROVED TEMPERATURE MEASURING APPARATUS. (to General Dynamics Corp.). British Patent 931,233. July 17, 1963. Priority date Oct. 28, 1960, United States.

The design of an acoustical thermometer, capable of measuring temperatures over a range of ~20 to 200°K, is patented. A gas-filled acoustical cavity is located in the

region of the temperature to be measured. An audio signal from a variable-frequency source is transmitted to the cavity and varied until the gas is induced to oscillate in a longitudinal resonant mode. A method for measuring the resonant frequency is provided, and the temperature within the cavity can be determined from the resonant frequency. Elongated coupling tubes extending from the cavity to an ambient temperature region connect the cavity to the signal source and detector. A single electroacoustic transducer may be used for both signal detecting and transmitting. (M.P.G.)

**32393** CONTINUOUS ROTATION SCATTERING CHAMBER. J. W. Verba and R. A. Hawrylak (to U. S. Atomic Energy Commission). U. S. Patent 3,100,263. Aug. 6, 1963.

An evacuated scattering chamber for use in observing nuclear reaction products produced therein over a wide range of scattering angles from an incoming horizontal beam that bombards a target in the chamber is described. A helically moving member that couples the chamber to a detector permits a rapid and broad change of observation angles without breaching the vacuum in the chamber. Also, small inlet and outlet openings are provided whose size remains substantially constant. (auth)

**32394** PULSE SYNTHESIZING GENERATOR. Quentin A. Kerns (to U. S. Atomic Energy Commission). U. S. Patent 3,100,284. Aug. 6, 1963.

An electronic circuit for synthesizing electrical current pulses having very fast rise times includes several sine-wave generators tuned to progressively higher harmonic frequencies with signal amplitudes and phases selectable according to the Fourier series of the waveform that is to be synthesized. Phase control is provided by periodically triggering the generators at precisely controlled times. The outputs of the generators are combined in a coaxial transmission line. Any frequency-dependent delays that occur in the transmission line can be readily compensated for so that the desired signal wave shape is obtained at the output of the line. (AEC)

**32395** ELECTRONIC INTEGRATING CIRCUIT. Rudolph H. Englemann (to U. S. Atomic Energy Commission). U. S. Patent 3,101,406. Aug. 20, 1963.

An electronic integrating circuit using a transistor with a capacitor connected between the emitter and collector through which the capacitor discharges at a rate proportional to the input current at the base is described. Means are provided for biasing the base with an operating bias and for applying a voltage pulse to the capacitor for charging to an initial voltage. A current dividing diode is conne ted between the base and emitter of the transistor, and signal input terminal means are coupled to the juncture of the capacitor and emitter and to the base of the transistor. At the end of the integration period, the residual voltage on said capacitor is less by an amount proportional to the integral of the input signal. Either continuous or intermittent periods of integration are provided. (AEC)

## Radiation Detection

*Refer also to abstracts 32915 and 32916.*

**32396** (AERE-R-3972) A METHOD OF OPTIMISING LIGHT COLLECTION IN SCINTILLATION COUNTERS. G. A. Gard and A. G. Hardacre (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). Apr. 1963. 22p.

A method was developed whereby the uniformity of response of a plastic scintillation detector to protons in the 10 to 50 Mev energy range may be estimated. A narrow beam of 660-kev $\gamma$ rays was used to simulate charged particles, and the spatial variations of the response to this radiation were investigated. Comparisons between the responses to protons and to $\gamma$ rays of two different detector geometries were made. Extension of the method to thin scintillators by use of x rays is discussed, and a description is given of the integrator and computer used. (auth)

**32397** (BNL-6848) ILLUMINATION OF 80-INCH BUBBLE CHAMBER. Seymour Rosin (Brookhaven National Lab., Upton, N. Y.). [1962]. Contract [AT(30-2)-Gen-16]. 43p. (CONF-26-1)

From Optical Society of American Meeting, Jacksonville, Fla., Mar. 1963.

A cylindrical condensing system whose geometry allows light to be collected along the length of narrow tubular sources and to pass through a restricted port area is used. The quantity of light collected is many times that possible to obtain with axially symmetric lenses. The optical arrangement is described. Other unique features include the use of plano reflectors to extend optically the flash tube and condenser lengths and the provision of a spot plate to eliminate surface reflections from the chamber window. (auth)

**32398** (CEA-2215) MESURE DE L'ACTIVITE DES GAZ EMETTEURS $\beta$ AU MOYEN D'UNE CHAMBRE D'IONISATION. (Measurement of the Activity of $\beta$ Emitting Gases Using an Ionisation Chamber). P. Lebouleux (France. Commissariat à l'Énergie Atomique. Centre d'Études Nucléaires, Saclay). July 1962. 105p.

An ionization chamber was developed for measuring directly the activity of a $\beta$-emitting gas whatever the gas may be. The following two parameters are defined and determined: $\bar{p}$, the average specific ionization produced by a $\beta$ desintegration, and $\bar{l}$, the average $\beta$ path in the chamber. It was shown, during the determination of $\bar{l}$, that the $\beta$ particles are reflected on the walls of the ionization chamber when the latter are made of a high atomic number material. It was possible to eliminate this effect by constructing an electrode chamber made of graphite. With this chamber a direct measurement can be made of the activity of a gaseous $\beta$ emitter with a precision of about $\pm 10\%$. Some applications are given of the graphite electrode chamber (calibration of the chambers built industrially and determination of the activation cross section of a gaseous emitter). It was possible to determine the activation cross section of $Xe^{134}$; a value of $0.18 \pm 0.03$ barn was found. (auth)

**32399** (HW-SA-2932) LOW LEVEL GAMMA SPECTROMETRY USING BETA-GAMMA COINCIDENCE. F. P. Brauer and R. E. Connally (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [June 12, 1963]. Contract [AT(45-1)-1350]. 17p. (CONF-39-23)

From American Nuclear Society Meeting, Salt Lake City, Utah, June 1963.

A general-purpose low-level beta-gamma detector is described. High sensitivity was obtained by centering the sample between two large sodium iodide crystals. The beta detector is of low mass to minimize gamma absorption and small diameter to maximize gamma counting efficiency. A logical circuit for multiplexing is shown. Possible counting modes for a typical coincident beta-gamma $Co^{60}$ source are compared. (M.C.G.)

**32400** (KFK-129) EIN VOLLAUTOMATISCHES WINKELKORRELATIONSPOLARIMETER ZUR UNTERSUCHUNG VON $\gamma$-$\gamma$-KASKADEN. (A Fully Automatic Angular Correlation Polarimeter for Study of $\gamma$-$\gamma$ Cascades). W. Michaelis (Kernforschungszentrum, Karlsruhe, Germany). Jan. 1963. 21p.

An apparatus is described that allows determination of angular distributions and polarization direction distribution in gamma-gamma cascades. The arrangement consists of three scintillation counters, A, B, and C. Coincidences between A and B serve for determination of the angular distribution. Counters B and C together form a polarization-sensitive detector. Measurement of the coincidences between the three counters A, B, and C yields the polarization direction distribution. In addition to the three scintillation detectors, the apparatus consists of two fast-slow coincidence systems, register installation, control port, and pulse-height analyzer. Test results on the 1170–1330 kev cascade of $Ni^{60}$ are presented. (M.C.G.)

**32401** (LNF-63/17) UN CIRCUITO PER MISURARE L'ENERGIA MASSIMA DELLO SPETTRO DI BREMSSTRAHLUNG CUI SI RIFERISCE UN DETERMINATO EVENTO. (A Circuit to Measure the Maximum Energy of the Bremsstrahlung Spectrum of a Given Event). Note No. 189. C. Dardini, C. Mencuccini, and V. Silvestrini (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Mar. 26, 1963. 6p.

A circuit to measure the maximum energy of the bremsstrahlung spectrum of a given event, which reduces the uncertainty caused by the duration of the beam, was designed and constructed. In substance, it consists of monovibrators in series in a time sequence such that the pulse duration of each monovibrator corresponds to an equal interval of electron energy. (J.S.R.)

**32402** (TID-19112) X-RAY BEAM QUALITY MEASUREMENTS UTILIZING TL DOSIMETERS. Gordon N. Kenney and John R. Cameron (Wisconsin. Univ., Madison). [nd]. Contract AT(11-1)-1105. 26p.

The differential energy response of two different thermoluminescence dosimeters (lithium fluoride and aluminum oxide) is used as the basis for x-ray beam quality measurements. The effects of radiation on the thermoluminescent properties of these two materials are evaluated both experimentally and theoretically. The lithium fluoride used in these measurements is similar to the TLD-100 phosphor available commercially. The $Al_2O_3$ is procured as RR Alundum Blue Label 60 mesh. (N.W.R.)

**32403** (UCRL-7169) THE SPARK CHAMBER AS A DETECTOR OF FISSION FRAGMENTS. Charles D. Bowman and Richard W. Hill (California. Univ., Livermore. Lawrence Radiation Lab.). Dec. 12, 1962. Contract W-7405-eng-48. 22p. (CONF-46-34)

From American Physical Society Meeting, Washington, D. C., April 1963.

The usefulness of a corona-type spark chamber for the detection of fission fragments in the presence of a very high alpha background was investigated. It was found that the ratio of detection efficiency for fission fragments compared to alpha particles can be made as large as $3 \times 10^7$ or better while retaining an efficiency of about 30% for fission fragments. The use of the detector in photon and neutron induced fission experiments is discussed. (auth)

**32404** (WCAP-2274) MINIATURE NEUTRON DETECTOR DEVELOPMENT. Quarterly Progress Report for Period January 1–March 31, 1963. J. Weisman (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). Work performed under United States–Euratom Joint Research and Development Program. Contract AT(30-1)-2827. 18p. (EURAEC-657)

The SiC junction diodes produced during the previous quarter were evaluated for alpha detection, and two were chosen for proton damage studies. The units were bombarded at room temperature with 2-Mev protons from the Van de Graaff generator. The first diode tested was somewhat more resistant to irradiation at room temperature than the best Si junction detectors, and the resistance was increased another order of magnitude by high-temperature annealing. Damage experiments on the second detector are continuing, but preliminary results show it to be more resistant to radiation than the first unit. Additional counting junctions were formed by both the finite and infinite source diffusion processes. These were fabricated into diodes and given a preliminary evaluation. A new diode base configuration suitable for in-pile irradiation was developed. (auth)

**32405** (ZFK-RN-19) LITHIUM-GLASSZINTILLATOREN ZUM NACHWEIS VON NEUTRONEN. (Lithium-Glass Scintillators for the Detection of Neutrons). Alexander Andreeff, Hans Guenter Byhan, Peter Manfrass, and Lothar Nolte (Germany. Zentralinstitut für Kernphysik, Dresden). May 1963. 8p.

A glass scintillator on a lithium basis was developed. The scintillator consists of a cerium-activated lithium silicate glass and contains 9 wt. % lithium of natural isotopics composition. The calculated effectiveness for neutrons with an energy of 1 Mev at 10 mm scintillator thickness amounted to about 22%. The gamma effectiveness in the region of the neutron peak for gamma quanta of 1.3 Mev is less than 1.7%. The average lifetime of the neutron in the detector is less than 0.5 $\mu$sec. The light yield of a 10-mm-thick scintillator is about 15% that of a NaI(Tl) crystal and increases with decreasing scintillator thickness. The decay period of the light impulse amounts to about 88 nsec. The maximum of the fluorescence radiation lies at 390 nm. (tr-auth)

**32406** CONTRIBUTION TO THE TECHNOLOGY OF THE COMPRESSION PREPARATION OF SCINTILLATION DISCS FOR THE DETECTION OF NEUTRONS. D. Ştefănescu and Il. Stănoiu (Inst. of Atomic Physics, Bucharest). Acad. Rep. Populare Romine, Studii Cercetari Fiz., 14: 143-57(1963). (In Rumanian)

The technology of the preparation of scintillation discs by compression techniques was studied to determine the conditions for the preparation of good neutron detectors. The $(n,\alpha)$ reaction on $B^{10}$ and $Li^6$ was used to study the efficiency of the counters. The basic material of the counters was $B^{10}$ or $Li^6$. Only partial results are as yet available on the efficiency of the counters. (tr-auth)

**32407** STUDY OF THE PREPARATION OF A NUCLEAR EMULSION WITH VERY FINE GRANULATION. A. Apostol, M. Nicolae, and R. Pop (Inst. of Atomic Physics, Bucharest). Acad. Rep. Populare Romine, Studii Cercetari Fiz., 14: 263-9(1963). (In Rumanian)

A method for the synthesis of nuclear emulsions with very fine granulation is given. It is a variant of the procedure proposed by Perfilov et al. A precipitation apparatus was constructed for preparation of the emulsions. The pAg of the liquid emulsion was kept at 6 during the precipitation. The mean diameter of the emulsion grains was evaluated as 0.07 $\mu$. The effect of the value of the pAg on the clouding and sensitivity obtained was determined. (tr-auth)

**32408** ANALYSIS OF THE CAUSES OF ERROR AND OF THE PRECISIONS OBTAINABLE IN THE OPERATION OF ANALOG TO DIGITAL CONVERSION. P. F. Manfredi

and A. Rimini (CESNEF, Milan). Energia Nucl. (Milan), 10: 301-14(June 1963). (In English)

The errors introduced in the three phases in which the operation of a Wilkinson type analog-to-digital converter can be divided, are analyzed. Following theoretical results, some design criteria are exposed, and three fully transistorized converters of increasing complexity are described. Linearity measurements of each converter and for different values of conversion constant are given. (auth)

**32409** A VARIABLE COINCIDENCE UNIT HASL TYPE TL-9. N. Latner, R. T. Graveson, and M. E. Cassidy (Atomic Energy Commission, New York). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 27-31(July 1963).

The variable coincidence gate is a multifunction logic unit designed for use with the HASL quarter chassis line of nuclear instrumentation. It provides a flexible unit that is applicable to several of the techniques used for counting radioactive events. The circuit can be used for prompt, delayed, and decay coincidence, anticoincidence, and pulse height window measurements. It also operates as a signal generator of paired pulses and of delayed pulses. The unit is 3½″ high by 9½″ wide and 6″ deep. (auth)

**32410** A LOW LEVEL BETA SCINTILLATION COUNTER. Melvin E. Cassidy and Robert T. Graveson (Atomic Energy Commission, New York). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 59-62(July 1963).

An automatic scintillation counter for the measurement of low beta activity samples is described. Background is in the order of one count per minute. Efficiency of counting for K-40 betas in thirty per cent. The scintillator is a thin plastic phosphor mounted on the sample that makes a simple, rugged package suitable for automatic sample changing. Photomultiplier tube noise measurements, preamplifier circuit, and the mechanical details are discussed. (auth)

**32411** EXPERIMENTAL CALIBRATIONS OF A SILICON RECTIFIER DEVELOPED AS A FAST NEUTRON SUB-MINIATURE DOSIMETER. John M. Swartz and Louis Browne (Army Electronics Research and Development Lab., Fort Mommouth, N. J.). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 63-9 (July 1963).

A wide-based, conductivity-modulated silicon junction rectifier that responds to fast neutron irradiation in the range of 10–1,000 rads, and whosé range undoubtedly can be extended upwards by one to two orders of magnitude is described. The device is a n-p-p diffused junction rectifier with a base width of 10 to 60 mils depending on the sensitivity desired. The dosimeter essentially does not respond to gamma radiation in the energy and dose ranges of interest. (C.E.S.)

**32412** THE BUBBLE CHAMBER. R. Budde (CERN, Geneva). Kerntechnik, 5: 241-7(June 1963). (In German)

The bubble chamber is at present the most widely used instrument for taking photographs of tracks of particles in high-energy physics. The general working principles of these chambers are explained, and their applications in the physics of elementary particles are discussed. Furthermore, some important details of the chambers operating at low temperatures on one hand and of the heavy liquid chambers on the other are described. (auth)

**32413** USE OF COMPLEX IONS IN THE EFFICIENCY TRACING METHOD FOR THE STANDARDIZATION OF PURE BETA-EMITTING NUCLIDES. T. T. Gorsuch, D. J. Jenkins, and C. A. Ludbrook (Radiochemical Center, Amersham, Bucks, Eng.). Nature, 199: 368(July 27, 1963).

A method for the standardization of pure $\beta$ emitters is presented. The technique involves the inclusion of a suitable $\beta-\gamma$-emitting nuclide with the pure $\beta$ emitter in the deposited source and the use of $\beta-\gamma$-coincidence counting to determine the efficiency of detection of the betas arising from the $\beta-\gamma$- or tracer nuclide. Knowledge of the $\beta$ efficiency for the tracer in a series of sources may then be used to determine the absolute activity of the pure $\beta$ emitter. Nuclides fulfilling the requirements for a simple decay scheme, which also have maximum $\beta$ energies of less than 1 Mev, are $Sc^{46}$, $Co^{60}$, $Br^{82}$, $Nb^{95}$, $Ce^{141}$, $Lu^{177}$, $Au^{198}$, and $Hg^{203}$. (P.C.H.)

**32414** SENSITIVITIES OF FUJI BADGE FILM TO $\beta$-RAYS AND EVALUATION OF $\beta$-RAYS DOSAGE. Ichiro Miyanaga, Kazuyoshi Bingo, and Hozumu Yamamoto (Japan Atomic Energy Research Inst., Tokyo). Nippon Genshiryoku Gakkaishi, 5: 497-503(June 1963). (In Japanese)

The sensitivities of Fuji Badge Film to $\beta$ rays were investigated using the isotopes $S^{35}$, $W^{185}$, $Tl^{204}$, $P^{32}$, $Sr^{90}-Y^{90}$, and natural uranium plaque. Plane sources for exposure were prepared, and the contact radiography showed the uniformity of the source to be within ±10% over the whole area, 5.5 cm$\phi$. The flux of $\beta$ particles was counted with a G-M counter calibrated by 4 $\pi$ flow counter. The surface doses were calculated about the mean energy of $\beta$ spectrum by Bethe-Bloch formula. The particle sensitivity was found to have a peak around 0.2 Mev in maximum energy which can be explained considering the relation between the range of $\beta$ rays and the thickness of emulsion coating. The dosage sensitivity was found to increase with $\beta$-ray energy and to be almost flat above 1.5 Mev in maximum energy. By using the results, it is shown how to estimate the apparent energy of incident $\beta$ rays and to evaluate the skin dose and the lens dose of eye with three plastic filters of Jaeri Film Badge, Model III. (auth)

**32415** EXPERIMENTAL DETERMINATION OF THE PHOTOFRACTION OF A CYLINDRICAL 4″ × 6″ NaI(Tl) SCINTILLATION DETECTOR. C. Weitkamp (Kernforschungszentrum, Karlsruhe, Ger.). Nucl. Instr. Methods, 23: 10-12(May 1963). (In English)

The photofraction of a NaI(Tl) crystal of 4-in. diameter × 6-in. length is determined for gamma rays between 0.32 and 2.76 Mev. The method used eliminates all perturbative effects except Compton scattering in the source which is corrected for analytically. (auth)

**32416** MONTE-CARLO CALCULATION OF PHOTOFRACTIONS AND INTRINSIC EFFICIENCIES OF CYLINDRICAL NaI(Tl) SCINTILLATION DETECTORS. C. Weitkamp (Kernforschungszentrum, Karlsruhe, Ger.). Nucl. Instr. Methods, 23: 13-18(May 1963). (In English)

A Monte-Carlo calculation of efficiencies and photofractions of NaI(Tl) detectors for gamma rays between 0.2 and 10.0 Mev is described. The crystals considered are right circular cylinders ranging in size from 3 in. diameter × 2 in. length to 5 in. diameter × 6 in. length. The results may be used to determine the optimum crystal dimensions for given crystal volume and gamma-ray energy. The influence of collimators of different apertures is investigated. Except two characteristic cases, however, results are given for uncollimated radiation only. (auth)

**32417** A SPARK CHAMBER WITH HIGH DETECTION EFFICIENCY. S. Fukui and B. Zacharov (European Organization for Nuclear Research). Nucl. Instr. Methods, 23: 24-8(May 1963). (In English)

Experiments are described in which spark chambers are operated with electrodes either of high resistance or covered with a high resistivity material. When the cham-

bers are driven with a single, short pulse or a damped r-f field, a high gap efficiency is obtained for the simultaneous detection of very many ionizing particles. The characteristics and operating conditions of the chambers are also discussed. (auth)

**32418** NEUTRON FLUX MEASUREMENTS BY RESONANCE ACTIVATION OF FOILS. A. M. Judd (United Kingdom Atomic Energy Authority, Thurso, Caithness, Scotland). Nucl. Instr. Methods, 23: 29-35(May 1963). (TRG-Report-399). (In English)

Various assessments of flux depression and self-protection by a foil irradiated in a diffusing medium are compared. From a consideration of self-protection for resonance activation, an evaluation of the "sandwich" technique of measuring neutron flux at resonance energies is made. (auth)

**32419** SCINTILLATOR MESON TELESCOPE FOR STUDIES OF COSMIC RAY INTENSITIES. H. Coxell, W. W. Fairchild, and M. A. Pomerantz (Bartol Research Foundation, Swarthmore, Penna.). Nucl. Instr. Methods, 23: 45-56(May 1963). (In English)

A meson telescope utilizing plastic scintillator detectors and capable of a counting rate exceeding $10^6$ counts per hour is described. The design considerations and operating characteristics of this type of instrument are discussed. A brief description of a more compact instrument suitable for airborne observations is included. (auth)

**32420** THE INTERPRETATION OF RECOIL PROTON SPECTRA. J. B. Parker, P. H. White, and R. J. Webster (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). Nucl. Instr. Methods, 23: 61-8(May 1963). (In English)

The influence of counter geometry on the measurement of proton recoil spectra, due to wall and end effect, is examined with the aid of an IBM 7030 Monte Carlo program. A second program, for use in interpreting spectra obtained from an asymmetrical solid state recoil counter, is also described. The programs are illustrated by practical examples. (auth)

**32421** BETA SPECTROSCOPY WITH SOLID STATE DETECTORS. H. Bosch, F. Krmpotic, and A. Plastino (Universidad Nacional, La Plata). Nucl. Instr. Methods, 23: 79-92(May 1963). (In English)

The optimum conditions are described for registering beta spectra and detecting conversion electrons with solid state counters. The error in determining the beta spectra energies from standard sources is pointed out. A fast-slow coincidence circuit was set up for detecting conversion electrons in coincidence with electromagnetic radiations by means of a system with solid state counter and scintillation crystal. The results obtained in the case of $Bi^{207}$, $Cs^{137}$, $Au^{198}$, and $Pb^{203}$ are given. (auth)

**32422** A DIFFUSION CLOUD CHAMBER DESTINED FOR THE MEASUREMENT OF THE POLARIZATION OF FAST NEUTRONS. J. L. Le Roy, S. Barkan, M. Dumazert, and C. Jousseaume (Centre d'Etude Nucléaires, Saclay, France). Nucl. Instr. Methods, 23: 93-103(May 1963). (In French)

A description of a diffusion cloud chamber having great dimensions and being able to operate at high pressure is given. The most effective operating conditions were determined. (auth)

**32423** TWO-DIMENSIONAL REGISTRATION IN COINCIDENCE BETWEEN JUNCTIONS AND PHOTOMULTIPLIERS. R. Ballini, E. Pomelas, and N. Saunier (Centre d'Etudes Nucléaires, Saclay, France). Nucl. Instr. Methods, 23: 117-21(May 1963). (In French)

A description of simultaneous registering of $\alpha$ and $\gamma$ spectra in coincidence and preliminary results concerning the reaction $Li^6 + Be^9$ are given. (auth)

**32424** DETECTION OF POSITRONS IN A MAGNETIC $\beta$-RAY SPECTROMETER BY MEANS OF THEIR ANNIHILATION RADIATION TO INVESTIGATE TRANSITIONS INVOLVING THE EMISSION OF POSITRONS WITH LOW INTENSITY. D. Berényi (Inst. for Nuclear Research, Hungarian Academy of Sciences, Debrecen). Nucl. Instr. Methods, 23: 125-8(May 1963). (In English)

For the detection of positrons, two scintillation counters equipped with specially designed NaI(Tl) crystals introduced into a $\beta$-ray spectrometer of toroid-sector type were used in coincidence. Thereby the study of positron transitions of low intensity ($10^{-4}$ to $10^{-5}$ positrons per disintegration) was possible while there was no cut-off whatsoever for positrons of low energy and the rejection ratio was practically infinite. (auth)

**32425** G.M. COUNTERS AS SWITCHING ELEMENTS IN THE COINCIDENCE AND ANTICOINCIDENCE CIRCUIT. B. J. Kovač, S. D. Muždeka, and M. V. Šobajić (Inst. of Nuclear Sciences "Boris Kidrich," Belgrad). Nucl. Instr. Methods, 23: 129-31(May 1963). (In English)

In the new coincidence and anticoincidence circuit, halogen G.M. counters are used as switching elements to select corresponding pulses so that additional electronic elements are not necessary. The anticoincidence circuit was successfully applied for measuring low-level beta activities by means of Philips counters types 18516 and 18518. (auth)

**32426** MEASUREMENT OF THE SLOW COMPONENT OF LUMINOUS EMISSION IN ORGANIC SCINTILLATORS; APPLICATION TO THE DISCRIMINATION OF PARTICLES ACCORDING TO THEIR IONIZING POWER. G. Walker and A. Coche (Centre de Recherches Nucléaires, Strasbourg). Nucl. Instr. Methods, 23: 147-51(May 1963). (In French)

A method to study the rate of decay of the slow component of luminescence in organic scintillators is discussed. The results for stilbene, anthracene, diphenylacetylene (tolan), terphenyl, plastic scintillator NE 102, and one liquid scintillator are presented. The same principle is applied for the design of a circuit useful for discrimination between particles of differing specific ionization. (auth)

**32427** ANGULAR CORRELATION ATTENUATION COEFFICIENTS FOR PHOTOPEAKS MEASURED WITH NaI CRYSTALS. M. J. L. Yates (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). Nucl. Instr. Methods, 23: 152-4(May 1963). (In English)

Angular correlation attenuation coefficients were computed with a Monte Carlo code for measurements with a $7.62 \times 7.62$ cm$^2$ NaI crystal. The calculations are based on the assumption that only the photopeak area is measured, and cover the range 1 to 10 cm, and 0.1 to 1.0 Mev. The results are compared with those derived assuming that the whole spectrum area is measured. (auth)

**32428** A SIMPLE CHARGED-PARTICLE DETECTOR FOR MAGNETIC ANALYZERS. V. Latorre, F. C. Young, and J. C. Armstrong (Univ. of Maryland, College Park). Nucl. Instr. Methods, 23: 159-61(May 1963). (In English)

A charged-particle detector which distinguishes and counts particles from a magnetic analyzer is described which uses a single photomultiplier tube whose output pulse height depends on the position of the input signal on the tube

face. The response characteristics of several tubes in conjunction with CsI(Tl) crystals for such use were studied using a $Po^{210}$ alpha source. It was found possible to construct a single phototube detection system whose output pulse height is linearly related to the position of the input light pulse, and resolution of 6 to 8% was found. (D.L.C.)

**32429** OPTIMUM CHANNEL WIDTH FOR SINGLE CHANNEL ANALYSIS. J. D. Reber and J. K. Major (Western Reserve Univ., Cleveland). Nucl. Instr. Methods, 23: 162-4(May 1963). (TID-17471). (In English)

An analysis is made of the pulse height distribution of a single-channel analyzer in order to minimize the relative statistical error in the net counting rate. Relations are derived for the optimum channel width, and graphs of the optimum width as a function of the background counting rate/observed counting rate ratio and the full width are given. (D.L.C.)

**32430** BETA-RAY SPECTROMETER WITH REDUCED SPHERICAL ABERRATION. A. M. Sessler (Univ. of California, Berkeley). Nucl. Instr. Methods, 23: 165-8(May 1963). (UCRL-10668). (In English)

An analysis is made of an azimuthally varying field beta spectrometer, and explicit formulas are derived for the spherical aberration through second order. It is shown by example that the aberration can be made to vanish. (D.L.C.)

**32431** A PROPOSAL FOR A NEW TYPE OF GAMMA SCINTILLATION SPECTROMETER. Y. Kalish (Weizmann Inst. of Science, Rehovoth, Israel and Beilinson Hospital, Petah-Tikva, Israel). Nucl. Instr. Methods, 23: 171-2 (May 1963). (In English)

A new type of multi-crystal spectrometer for high-energy gamma rays (> 2 Mev) is proposed which has an expected efficiency of ~ 10% in the above energy range. The spectrometer is to be composed of a 256-crystal scintillation assembly, an image orthicon, logic elements, electronic circuits, and a multi-channel analyzer. Pulses from the assembly are passed to the analyzer only when three of the crystals emit light simultaneously, two of the three crystals emit light whose intensities correspond to an energy loss of ~ 0.5 Mev, and the three crystals lie on a straight line. (D.L.C.)

**32432** ON THE RESPONSE TO FAST NEUTRONS OF A $BF_3$ COUNTER IN A PARAFFIN SPHERICAL-HOLLOW MODERATOR. M. Ladu, M. Pelliccioni, and E. Rotondi (CNEN, Frascati, Italy). Nucl. Instr. Methods, 23: 173-4 (May 1963). (In English)

A system having a uniform angular response to fast neutrons was constructed which comprises a $BF_3$ counter placed into a hollow sphere of paraffin. The angular response was studied using a Po–Be source and found to deviate from the average by less than 2%. The system also obeys the inverse square law, behaving like a point detector with the center at the geometrical center. (D.L.C.)

**32433** A PROGRAMMED CONTROL SYSTEM FOR AN AUTOMATIC NEUTRON SPECTROMETER. D. Allenden and R. Winkworth (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). Nucl. Instr. Methods, 23: 181-92(June 1963). (In English)

The automatic control and programming system of the neutron spectrometer which is fitted to the MERLIN reactor is described. The system allows a complete experiment involving up to 600 angular positions and four specimens to be pre-programmed and carried out automatically. The control logic and circuitry are described. (auth)

**32434** THE RELATIONSHIP BETWEEN THE SPEED OF RESPONSE OF A LINEAR RATEMETER AND THE AMPLITUDE OF ITS RANDOM FLUCTUATIONS. C. H. Vincent (Atomic Energy Research Establishment, Aldermaston, Berks, Eng.). Nucl. Instr. Methods, 23: 193-6 (June 1963). (In English)

There is a relationship between the fluctuation of the reading of a ratemeter for a random input and its speed of response. This relationship is put into a quantitative form by deriving a minimum fluctuation that is possible for a given speed of response. The theory of a linear ratemeter is considered in a general form, which does not assume the normal decreasing exponential response to a single input pulse that is characteristic of the ordinary diode-pump ratemeter. As a reciprocal measure of the speed of response of the ratemeter, an average delay L in the reading is defined. L is the actual time lag with which the reading follows the rate, if $\rho$ is subject to a smooth, slow variation. (In the exponential case, L equals the time constant). It is shown that for a ratemeter designed to have a specified value of L, without overshoot, there is a minimum ratio of root mean square random fluctuation to mean reading, for randomly timed input pulses at a mean rate $\rho$, which is $\sqrt{4/9\rho L}$. The normal exponential response gives a ratio only 6% higher than this. (auth)

**32435** THE INFLUENCE OF ELECTRON STRAGGLING ON $\gamma$-RAY ENERGY DETERMINATION BY THE EXTERNAL CONVERSION METHOD. P. F. A. Goudsmit (Instituut voor Kernphysisch Onderzoek, Amsterdam). Nucl. Instr. Methods, 23: 203-8(June 1963). (In English)

The energy shift of photoelectrons from external conversion produced by the inelastic scattering of the photoelectrons by the converter atoms is calculated. The 2754-kev $\gamma$ in $Mg^{24}$ is measured by the external conversion method and the experimental energy determination is corrected for this energy shift. (auth)

**32436** A NANOSECOND PULSE HEIGHT DISCRIMINATOR. C. B. Ward and C. M. York (Univ. of California, Los Angeles). Nucl. Instr. Methods, 23: 213-17(June 1963). (In English)

A pulse height discriminator for nanosecond pulses is built employing tunnel diodes. The discriminator accepts negative pulses from 0.5 to 10.0 v in height, with rise times from 0.5 to 20 nsec and durations from 5 to 100 nsec. The threshold voltage for discrimination is set in terms of a calibrated potentiometer on the front panel of the circuit. The "jitter" of the threshold is a maximum of ±10 mv over the entire range of threshold settings, and the maximum time variation in the leading edge of the output pulse as a function of the excess above threshold for the input is 10 nsec. Two output pulses are provided: one is a −5v pulse into 50 ohms, with a rise time of 3 nsec and duration of 30 nsec; the second is a +8v pulse with 10 nsec rise time and 100 nsec duration to drive a scaling circuit directly. Although used in a 50 ohm counting system, modifications of this circuit for use with higher impedance systems are described. (auth)

**32437** SOME CONSIDERATIONS OF THE ADDRESS LOGIC OF A KICKSORTER EMPLOYING ADC. P. K. Patwardhan and M. D. Mahajan (Atomic Energy Establishment, Trombay, India). Nucl. Instr. Methods, 23: 225-8 (June 1963). (In English)

A logic for the address register of a pulse-amplitude analyzer, employing amplitude-to-digital conversion (ADC) and having 10 to 20 channels, is suggested. The logic eliminates the non-linear behavior arising in these systems and is successfully used in a practical 10-channel system. (auth)

**32438** ELECTRONIC EQUIPMENT FOR A ČERENKOV RADIATION DETECTOR. R. Thorn (Associated Electrical Industries, Ltd., Aldermaston, Berks, Eng.). Nucl. Instr. Methods, 23: 237-44(June 1963). (In English)

The electronic circuits for a Čerenkov radiation detector using a coincidence method of photomultiplier noise reduction are described. A brief account of performance is given. (auth)

**32439** A TOTAL ABSORPTION SPECTROMETER FOR MEASURING THE ENERGIES OF NUCLEAR INTERACTING PARTICLES OF THE COSMIC RADIATION IN THE ENERGY RANGE OF A FEW Gev TO A FEW HUNDRED Gev. P. V. Ramana Murthy, B. V. Sreekantan, A. Subramanian, and S. D. Verma (Tata Inst. of Fundamental Research, Bombay). Nucl. Instr. Methods, 23: 245-54 (June 1963). (In English)

An instrument referred to as a "total absorption spectrometer" (of area 1.4 $m^2$ and solid angle = 0.25 steradians) is constructed for measuring the energies of nuclear interacting particles of the cosmic radiation in the energy range of a few Bev to a few hundred Bev. The general features of the design, construction and the procedure used for calibration are discussed, as are the factors that govern the accuracy (~20%) of energy measurement. (auth)

**32440** A PHOTOPROTON TELESCOPE. O. M. Mracek Mitchell and K. G. McNeill (Univ. of Toronto). Nucl. Instr. Methods, 23: 255-60(June 1963). (In English)

A scintillation counter telescope is described that can be used for the detection of protons ($E_p$ > 3.7 Mev) emitted in photonuclear reactions produced by x rays from a betatron. Thin sheets of plastic phosphor are mounted on two photomultipliers, and the output pulses trigger a fast coincidence circuit. Alpha sources are used to calibrate the counters. Typical counting rates for photoprotons are given, and possible background reactions are discussed. (auth)

**32441** METHOD FOR THE ELIMINATION OF SUPERPOSED PULSES IN NUCLEAR SPECTROSCOPY. Gy. Mathe (Inst. of Nuclear Research, Hungarian Academy of Sciences, Debrecen). Nucl. Instr. Methods, 23: 261-3 (June 1963). (In English)

Superposition of a large number of small pulses produces a background in the higher energy region that is difficult to calculate. By a shape discrimination, the background arising from superposition can be considerably reduced, and the intensity of the remaining background can be measured. (auth)

**32442** PROPERTIES OF TRIGGERED MULTI-WIRE SPARK COUNTERS OF THE ROSENBLUM TYPE AND OF PARALLEL-PLATE SPARK COUNTERS. M. A. Meyer (Potchefstroom Univ. for C.H.E., South Africa). Nucl. Instr. Methods, 23: 277-86(June 1963). (In English)

A study is made of the properties of triggered multiwire spark counters consisting of a wire grid and a flat metal plate. These properties are compared with those of a parallel-plate spark counter. Measurements are carried out on the effects of the polarity, duration and delay of the high-voltage pulse, clearing field, separation between the electrodes, and air content. A simple explanation is given for the effects of the clearing field and the delay of the high-voltage pulse. (auth)

**32443** ACCURACY OF TRACK LOCATION OF CHARGED PARTICLES IN TRIGGERED MULTI-WIRE SPARK COUNTERS. M. A. Meyer, J. W. Koen, and I. J. Lessing (Potchefstroom Univ. for C.H.E., South Africa). Nucl. Instr. Methods, 23: 287-301(June 1963). (In English)

A study is made of the accuracy with which the spark in an argon-filled triggered multiwire spark counter used in conjunction with neon lamps, defines the position of the trajectory of the triggering particle at a given level. For a single counter, it is found that the distribution of the separation between the spark and the trajectory is given by the sum of two Gaussians having relative intensities of 0.95 and 0.05 and standard deviations that increase with increasing delay between the traversal of the particle and the application of the high-voltage pulse. The standard deviation of the major group is found to be 0.48, 0.55, and 0.81 mm for delays of 1, 2, and 7 microseconds respectively. In addition to the above distributions, large deviations are also observed that are explained in terms of photon-induced sparks. (auth)

**32444** SCINTILLATION AND PARTICLE DISCRIMINATION PROPERTIES OF CsBr(Tl) AND RbI(Tl) CRYSTALS. D. Klinger, R. Langkau, and H. Walter (Institut für Experimentalphysik, Hamburg). Nucl. Instr. Methods, 23: 302-4 (June 1963). (In German)

The scintillation decay and the pulse-shape discrimination properties of Tl-activated CsBr and RbI crystals are studied in the temperature range from −60 to +250°C. The decay depends in a characteristic way on the temperature of the crystal and the type of particle used. It is shown that the differences in shape between gamma and alpha pulses are sufficient to be used for pulse-shape discrimination. (auth)

**32445** THE ENERGY VARIATION OF THE SENSITIVITY OF A POLYETHYLENE MODERATED $BF_3$ PROPORTIONAL COUNTER. R. Fraeki, M. Leimdoerfer, and S. Malmskog (Aktiebolaget Atomenergi, Stockholm). Nucl. Instr. Methods, 23: 341-8(June 1963). (In English)

The variation with neutron energy of the sensitivity of a polyethylene-moderated boron counter is investigated experimentally at 2.3 Mev, 550 kev, 210 kev, 110 kev, 340 ev and 5 ev, and theoretically by the multigroup diffusion method in the same range. Different moderator thicknesses up to 10 cm are considered. Results show agreement between experimental and theoretical sensitivities for the kev and Mev energies, while a discrepancy of the order of a factor 2 at the most is obtained in the ev region. (auth)

**32446** APPARATUS FOR THE MEASUREMENT OF $\alpha-\gamma$ ANGULAR CORRELATIONS. W. C. Cobb (Massachusetts Inst. of Tech., Cambridge). Nucl. Instr. Methods, 23: 353-6(June 1963). (In English)

Equipment for measuring $\alpha-\gamma$ angular correlations is described. The detectors employed are a 2" × 2" NaI(Tl) crystal for γ rays and a silicon surface barrier counter for α rays. At an energy of 6 Mev, the α counter achieves a resolution of 100 kev at 5700 counts per second, and provides a signal suitable for a coincidence circuit with a $9 \times 10^{-9}$ sec resolving time. (auth)

**32447** VERY LARGE BORON TRIFLUORIDE PROPORTIONAL COUNTERS. I. L. Fowler (Atomic Energy of Canada Ltd., Chalk River, Ont.). Rev. Sci. Instr., 34: 731-9(July 1963).

More than 50 very large $BF_3$ counters, each approximately 6 ft (180 cm) long and 6 in. (15 cm) in diameter were made for cosmic-ray monitors. During the fabrication of these counters, the characteristics at varying gas pressures were studied and the alpha backgrounds of the various metals used for cathodes were determined. The counters have excellent characteristics at pressures up to 30 cm Hg and perfectly acceptable characteristics to 60 cm Hg pressure. With anode diameter 0.008 in. (0.2 mm) and gas amplification 35, the operating voltage for a filling of 20 cm Hg pressure of pure $BF_3$ is 2800 v; at 30 cm Hg it is 3400 v. Counters with copper cathodes

have backgrounds due to residual alpha contamination of about 2 counts/min, and with stainless steel cathodes, about 5 counts/min. Using a $BF_3$-Ar filling, a value of 6.30 ± 0.05% was obtained for the branching ratio of the $B^{10}(n,\alpha)Li^7$ reaction. (auth)

**32448** THERMOLUMINESCENT DOSIMETER READING SYSTEM. G. N. Kenney, J. R. Cameron, and D. Zimmerman (Univ. of Wisconsin, Madison). Rev. Sci. Instr., 34: 769-71(July 1963).

Two instruments were developed for measuring the thermoluminescence of LiF. The "clinical reader," suitable for routine clinical use, is simple and convenient to use. It has a standard deviation of from 1 to 5% and its components cost approximately $500. The "research reader" is more versatile and produces glow curves. Both readers use a 35-mg sample of loose powder and can be used with a variety of thermoluminescent materials. (auth)

**32449** IMPROVED NOBLE LIQUID SCINTILLATION COUNTER. J. R. Kane, R. T. Siegel, and A. Suzuki (Carnegie Inst. of Tech., Pittsburgh). Rev. Sci. Instr., 34: 817-18(July 1963).

The counter comprises a Dewar vessel whose helium reservoir terminates in a sapphire window, and a photomultiplier operating in vacuum below the window. Diphenylstilbene is used as a wavelength shifter. Some resolution and pulse height measurements on the counter are given. The resolution was ~11% for liquid helium and an alpha source, but it increased with the source distance from the window. (D.L.C.)

**32450** OBSERVATIONS ON THE OPERATION OF A DIFFUSION-CONDENSATION CHAMBER UNDER NORMAL PRESSURE. Gheorghe Văsaru and Ioan Pop. Studia Univ. Babes-Bolyai, Ser. 1, No. 1, 183-9(1959). (In Rumanian)

A cylindrical cloud chamber operating at atmospheric pressure was constructed. Both ethyl alcohol and methyl alcohol were used as the vapor source, and the coolant is a mixture of carbon dioxide and acetone. The vertical temperature gradient at the interior of the chamber was measured, establishing thus the optimum gradient for obtaining good quality tracks. The thickness of the sensitive layer was about 2.5 cm, and the temperature gradient in the sensitive region was 20.5°C/cm. The mean gradient in the chamber was 4°C/cm. The temperature gradient was measured with a copper-constantan thermocouple. It was determined by an analysis of the effect of the electric field on the tracks obtained that good quality tracks could be obtained for 45 to 50 v/cm. (tr-auth)

**32451** SOME PROBLEMS OF PHOTO-MULTIPLIER TUBES. King Lu (Lu King) and Ta-cheng Wang. Wu Li Hsueh Pao, 17: 229-36(May 1961).

Fundamental problems of different types of photomultiplier tubes for scintillation uses are described. The relation between the parameters of the photomultiplier tube and its application is discussed. The status of photocathodes, secondary emissive surfaces, and photomultipliers is discussed. The structure between the cathode and the first dynode, and the dynode structure, is reviewed. Improvements for the photomultiplier, photocathode, and dynode structures are described. (auth)

**32452** THE CAVITY CHAMBER MEASUREMENT OF DOSE RATE OF RADIUM γ-RAYS. Ren-Yu Hu. Wu Li Hsueh Pao, 18: 527-39(Oct. 1962). (In Chinese)

The characteristics of cavity chambers of different wall material (graphite, bakelite, Al) and different volume are studied. Using this method, the dose rate of γ rays of Ra is obtained. The experimental result is (corrected for density effect of wall material) 8.74 ± 0.27 γ/mg/hr, at 1 cm off the source. Using the correction factor of the different thicknesses of Pt packing of Laurence, this value becomes 8.15 ± 0.27 γ/mg/hr. This result is in good agreement with previous works within the experimental errors. (auth)

**32453** THE IONIZATION-MOMENTUM RELATION FOR VARIOUS TYPES OF PARTICLES IN THE RELATIVISTIC REGION. K. I. Alekseeva, G. B. Zhdanov, M. I. Tretyakova, and M. N. Shcherbakova (Lebedev Inst. of Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1862-8 (June 1963). (In Russian)

Experimental data pertaining to the momentum dependence of blob density on the tracks of charged particles are obtained for electrons in the 0.05 to 5 Bev/c momentum range and for protons and π mesons in the 1.4 to 19 Bev/c and 0.3 to 6 Bev/c momentum ranges. These data confirm the conclusion that for $\rho\beta c > 200\ mc^2$, instead of a plateau on the ionization–momentum curve, a drop is observed, which is in agreement with theoretical calculations in which radiative corrections are introduced. (auth)

**32454** VERTICAL ARM SPECTROMETER (Engineering Materials). (Brookhaven National Lab., Upton, N. Y.) (CAPE-1002)

The vertical-arm spectrometer, completed in 1962, is designed to avoid the useless space swept by a horizontal spectrometer. The instrument is one of the neutron spectrometers used at the graphite Brookhaven Research Reactor. This unit, using a vertical beam hole on top of the reactor, raises the arm through 60°. This arm, which is attached to a five-ton cylindrical crystal shield, supports the beam tube and a one-ton neutron detector. The detector is located five meters from the crystal. A steel frame guides two elevating chains that are used to raise and lower the arm. This frame acts as a safety device by locking the arm if the chains fails. (F.E.S.)

**32455** EXPERIMENTAL NUCLEONICS. B. Brown. Englewood Cliffs, N. J., Prentice-Hall Inc., 1963. 250p. $8.95.

Information on radioactivity, interaction of radiation with matter, detection of charged particles and electromagnetic radiation, neutron properties and detection, electronics, and health physics is included, along with experiments on determination of physical constants, electronics, counting systems, radioactivity, neutron detection and properties, and health physics and photographic techniques. Health and safety precautions are stressed with detailed instructions provided for the safe handling of radioactive material and waste disposal. Explanatory graphs, line drawings, and photographs are also included. (P.C.H.)

**32456** TEKHNIKA IZMERENII RADIOAKTIVNYKH PREPARATOV (Measuring Techniques for Radioactive Preparations). V. V. Bochkarev. Moscow, Gosatomizdat, 1962. 216p.

Nineteen articles are included on apparatus and techniques for measuring radioactivity. Semiconductors and ionization chambers for measuring α and β emissions are described, and methods for measuring gaseous and aerosol radioactivity are discussed. Spectrometric techniques for radioactive isotope identifications and applications of various magnetic β spectrometers and scintillation γ spectrometers with various auxiliary installations and devices are analyzed. (R.V.J.)

**32457** ON INCREASING THE SENSITIVITY OF FILM MEASUREMENTS OF GAMMA RADIATION INTENSITIES. Allen Brodsky (Univ. of Pittsburgh). 6p. (CONF-46-58)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Studies of the sources of error and the limits of sensitivity in film measurements of gamma radiation dose were made in preparation for an evaluation of low-level exposures to human populations. These studies showed that personnel monitoring films are inherently capable of measuring dose levels of a magnitude comparable to doses from natural background radiation. To take fuller advantage of the inherent sensitivity of the photographic emulsion, a multiple-reflection density amplifier was constructed that can be attached to ordinary densitometers to amplify net density readings by factors of 10 to 50. Some improvement in sensitivity was achieved, but further improvements are limited by present film processing techniques. (auth)

**32458** SILICON p-n JUNCTION RADIATION DETECTORS FOR TELSTAR. T. M. Buck, G. H. Wheatley, and J. W. Rodgers (Bell Telephone Labs. Inc., Murray Hill, N. J.). 6p. (CONF-68-1)

From Electrochemical Society, Pittsburgh, Apr. 1963.

The communication satellite Telstar carries four silicon p-n junction diode detectors. One is used to detect electrons with energies between 0.25 and 1.06 Mev, and the other three are for protons in three energy ranges: 2.8-25 Mev, 22-32 Mev, and 40-80 Mev. Pulses from all four are fed into a simplified, compact pulse height analyzer. After five months in operation, the internal consistency of the Telstar radiation data and their agreement with other data indicate that the detectors are performing well. In addition to the four detectors actually flown on Telstar, many more were fabricated and tested and used on other flight models and prototype models of Telstar and on Relay and Explorer XV. (A.G.W.)

**32459** DETECTOR FOR RADON MEASUREMENTS AT VERY LOW LEVEL. Elvira R. Di Ferrante, Eric Gourski, and René R. Boulenger (Centre d'Etude de l'Energie Nucléaire, Mol, Belg.). 10p. (CONF-16-11)

From International Symposium on the Natural Radiation Environment, Houston, Tex., Apr. 1963.

A scintillation detector was developed for the determination of very low radium contents by the emanation technique. The detector comprises a lucite cylinder with a spherical cavity covered by ZnS. A photomultiplier and a cathode follower are used to transmit the signal to a scaler. Results are given of studies of the detector performance. A background of 0.5 ± 0.1 cph was found, but repeated evacuations and refillings of He are necessary to eliminate the memory effect of lucite. Results are given of analysis of teeth using the detector; levels of 0.005 to 0.02 $\mu\mu$g $Ra^{226}$/g ash were found. (D.L.C.)

**32460** LOW GAMMA AND NEUTRON FLUXES CHEMICAL DOSIMETRY. A. Faucitano, V. Maxia, M. A. Rollier, and A. Rosenstein (Università, Pavia, Italy). 10p. (CONF-39-7)

From American Nuclear Society Annual Meeting, Salt Lake City, June 1963.

Attempts were made to expand the practical sensitivity of chemical dosimetry down to fluxes of $10^5$ n/cm$^2$/sec. Dosimeters were tested in a subcritical assembly, which yields a neutron flux of about $1.3 \times 10^5$ n/cm$^2$/sec and a $\gamma$ field of about 290 n/cm$^2$/sec when used with a 5-C Pu–Be source. When the Pu–Be source is used together with a Ra–Be source, a flux of $0.758 \times 10^5$ n/cm$^2$/sec, and a gamma field of 195 r/hr are obtained in the irradiating position nearest to the source. The results were obtained by the use of $Fe^{59}$ as a tracer to enhance the monitoring of the $Fe^{3+}$ produced and by the addition of sensitizers. (P.C.H.)

**32461** IMPROVEMENTS IN OR RELATING TO IONISATION CHAMBERS. (to Landis & Gyr AG). British Patent 930,923. July 10, 1963. Priority date June 9, 1960, Switzerland.

An ionization-chamber pocket dosimeter with magnetically actuated charging means is patented. A flexible conductor of ferromagnetic material is placed in the ionization chamber between the capacitor electrode and a stationary electrical contact. Normally, it is separated from the electrode, the contact, or both. When the capacitor is to be recharged, the dosimeter is placed in a strong magnetic field, which deflects the flexible conductor until an electrical connection is made between the capacitor electrode and the stationary contact. The flexible conductor may be a cylindrical helical spring, and may be connected within the dosimeter in a variety of ways. (M.P.G.)

**32462** IMPROVEMENTS IN DEVICES FOR DETECTING AND IDENTIFYING RADIOACTIVE ELEMENTS, IN PARTICULAR FOR GEOPHYSICAL PROSPECTION. Claude Lallemant and Jean Goitton (to Commissariat a l'Energie Atomique). British Patent 931,515. July 17, 1963. Priority date Apr. 10, 1959, France.

A device for indicating the presence of at least two $\gamma$-ray-emitting elements is patented. The device uses a single scintillation detector and discriminators corresponding to wide energy bands. The signals from the discriminators are combined by a differential galvanometer or ratio meter to give the difference or quotient of the input signals. One input signal depends upon the presence of one radioactive element, such as U, and the second signal depends upon a second radioactive element, such as Th. The device may be operated by unspecialized persons and is especially suitable for aerial prospecting. (M.P.G.)

**32463** IMPROVEMENTS IN OR RELATING TO RADIATION MEASURING DEVICES. (to General Dynamics Corp.). British Patent 931,821. July 17, 1963. Priority date Nov. 21, 1960, United States.

The design of a radiation-measuring device for measuring both the peak intensity and total energy of a pulse of radiant energy is patented. The device may be employed to measure pulses of $\gamma$ rays, $\beta$ particles, or neutrons. A detector converts a pulse of radiant energy into a d-c signal proportional to the intensity of the pulse. Two circuits are connected to the detector, one for integrating the current and the other for determining the maximum instantaneous value of the current and storing the information. An indicator is selectively coupled to both circuits. Design details are explained by a circuit diagram, which includes values of resistances and capacitances in the various circuits. (M.P.G.)

**32464** METHOD FOR OBTAINING COMPARABLE PHOTOGRAPHS OF THE OSCILLOSCOPE DISPLAY WHEN ANALYZED BY THE GRAY-WEDGE TECHNIQUE. Erich Sattler (to Siemens & Halske AG). German Patent 1,147,327. Apr. 18, 1963. Filed May 10, 1962.

When a pulse spectrum is analyzed by the gray-wedge technique, photographs of the oscilloscope display can not easily be compared, as the blackening depends on the exposure time and the pulse rate. These difficulties can be overcome if the amount of events taken per photograph is constant for each of the photographs. Therefore, a counter is provided for counting the incoming pulses. After a predetermined amount of pulses has arrived, the input of the spectroscope is switched off automatically by a counter-controlled relay circuit. (Gmelin Inst.)

**32465** DEVICE FOR MEASURING THE INTENSITY OF IONIZING RADIATION CONSISTING OF A MIXTURE OF KNOWN COMPONENTS OF VERY DIFFERENT IN-

TENSITIES. Adolf Trost (to Laboratorium Rudolf Berthold). German Patent 1,148,027. May 2, 1963. Filed July 14, 1962.

The device described comprises scintillators or proportional counters the output of which is a function of the radiation energy and of the operating voltage of the detectors, and of a condensator into which the output pulses are fed via a rectifier. A leak resistance is switched in parallel to the condensator. The elements of this discharge circuit are calibrated so that the time constant is much larger than the average time interval between two succeeding pulses from the most energetic radiation components of the high intensity, but small compared with the average time interval between two succeeding pulses from the still more energetic components of lower intensities, e.g., cosmic radiation. The average value of the condensator charge controls the detector voltage to keep it constant. A detailed description of the circuit is given. (Gmelin Inst.)

**32466** DRIFT CONTROL IN AN ANALYTICAL GAMMA RAY SPECTROMETER. L. E. Fite (to U. S. Atomic Energy Commission). U. S. Patent 3,101,409. Aug. 20, 1963.

A device for automatically and continuously controlling the over-all drift of a multi-channel analyzer so as to permit the accurate processing of spectrometric analytical data by a digital computer is described. Two sources of reference pulses, one of which is stored in the lower channels and the other being stored in the higher channels of a 256 channel analyzer, are provided. The reference pulses are processed in the same manner as the data pulses. The channels that should contain the reference pulses and the adjacent channels above and below those channels are monitored by comparison circuits such that any drift, upward or downward, of the reference pulses is detected to effect a change in high voltage supply in response to a drift in the upper channel, and to effect a change in the lower discriminator level of the analog to digital converter of the analyzer in response to a drift in the lower channel, thereby maintaining the pulses in the proper channels. (AEC)

# ISOTOPE SEPARATION

**32467** (CONF-8-5) FACTORS AFFECTING THE DESIGN CRITERIA OF GASEOUS THERMAL DIFFUSION SEPARATION SYSTEMS. W. J. Haubach (Mound Lab., Miamisburg, Ohio). [1962]. Contract [AT(33-1)-Gen-53]. 15p.

From American Inst. of Chemical Engineers Meeting, Buffalo, N. Y., May 1963.

A review of the Jones & Furry treatment of thermal diffusion is presented and the parasitic remixing term which cannot be evaluated theoretically is discussed. A method is described for obtaining an approximation to the $K_p$ term and the use of the "effective length" factor is discussed. The column design obtained at Mound in an attempt to minimize these effects is given. Choosing the hot wall temperature, the effects of impurities in the feed gas, and methods of column coupling are also discussed. (auth)

**32468** (TID-18966) AN INVESTIGATION OF SOME PROBLEMS INVOLVED IN THE SEPARATION OF MULTICOMPONENT MIXTURES HAVING SMALL SEPARATION FACTORS. T. C. Tucker (Oak Ridge Gaseous Diffusion Plant, Tenn.). June 5, 1963. Contract W-7405-eng-26. 105p. (KOA-1160)

A theoretical study was made of the fractionation of multicomponent mixtures having steady state separation factors similar to relative volatility and very nearly 1.0. A system of differential equations application to stagewise or continuous processes was developed. This model is primarily useful in isotope separation for plant design and operation. A method enabling integration at constant interstage flow was developed. The matched concentration cascade was studied as a design tool. It was shown to be a member of a continuous family. Approximate solutions of the differential equations were obtained for mixtures of two major components and any number of trace components. Enrichment of the middle component of some three-component mixtures was studied in simple matched concentration enrichers off infinite reservoirs. Little enrichment was found possible. A generalized form of matched abundance ratio cascades, referred to as $\overline{\psi}$-$\Delta\psi$ cascades, was also studied. It was found that, in general, only one abundance ratio may be matched between sidestreams. This is in contrast to the case in end sections, where any pair of components has matched abundance ratios if its average separation factor is equal to that of a matched abundance ratio pair. Again, it was found that middle component enrichment is limited in single, simple cascades. Equations were developed for a single $\overline{\psi}$-$\Delta\psi$ cascade with one side withdrawal stream. It was found that an arbitrarily pure middle component may be produced in the sidestream. A gaseous diffusion plant was found to be decidedly inferior to a plant consisting of two simple cascades. (auth)

**32469** EVALUATION OF THE PERFORMANCE OF THERMAL DIFFUSION COLUMNS SEPARATING XENON ISOTOPES. Samuel Blumkin and Edward Von Halle (Union Carbide Nuclear Co., Oak Ridge, Tenn.). A.I.Ch.E. (Am. Inst. Chem. Engrs.) J., 9: 541-7(July 1963). (TID-14416)

Three thermal diffusion columns of the hot-wire type were employed to test their effectiveness in the separation of $Xe^{131}$ from $Xe^{136}$. The procedure used to analyze the data is described and the experimentally derived values for the column separation parameters were compared with those predicted by theory. The results establish an empirical basis for the design of a thermal diffusion plant for the separation of Xe isotopes. (P.C.H.)

**32470** A STUDY OF MASS TRANSFER IN THE SEPARATION OF ISOTOPES BY CHEMICAL EXCHANGE AND BY DISTILLATION. V. A. Kaminskii. At. Energ. (USSR), 14: 586-8(June 1963). (In Russian)

A high value for the plate height (HEP) in the separation of isotopes by chemical exchange decreases the advantage of a high separation coefficient $\alpha$ for chemical exchange as compared to the separation of isotopes by distillation. Mass transfer was considered in the separation of $N^{15}$ by chemical exchange of NO and 10N $HNO_3$, and in the separation of boron isotopes by distillation of $BF_3$. For the separation of isotopes, when $(\alpha - 1) \ll 1$, HEP = G/aK, where G is the gas flow in moles, a is the contact surface between the two phases per unit volume of the column, and K is the total mass transfer coefficient. K can be expressed in terms of the film coefficients of mass transfer in the gas and in the liquid: $(1/K) = (1/k_g) + (1/k_l)$. At small column flows, the value of $k_l$ is constant, and the ratio of the liquid to gas resistances, $(1/k_l):(1/k_g)$ can be determined by a plot of HEP/G versus $(1/Re_g^{0.8})$. Experiments on a packed column 11 mm in diameter showed that the greater part of the film resistance is in the liquid film for the separation of $N^{15}$ by exchange between NO and $HNO_3$. The principal resistance to mass transfer occurred in the gas phase in the separation of boron isotopes by the distillation of $BF_3$. (TTT)

**32471** METHODS FOR THE SEPARATION OF STABLE ISOTOPES. I. THE CHARACTERISTICS OF THE SEPARATION INSTALLATIONS. TERMINOLOGY. Gh. Vasaru (Inst. of Atomic Physics, Cluj). Rev. Chim. (Bucharest), 14: 223-8(Apr. 1963).

Various terms used in isotope separation theory, such as separation element, stage, cascade, and ideal cascade are defined. A derivation for the equations relating to the minimum number of stages required and refluxing and the separation itself is discussed. (OTS)

**32472** ISOTOPE SEPARATION PRINCIPLES. Manson Benedict. 43p. (CONF-14-27)

From American Chemical Society Meeting, Mar.-Apr. 1963.

Isotope separation theory of ideal cascades is discussed. It is shown how the most important characteristics of an isotope separation process can be worked out from the compositions and flow rates of the feed and product streams. These characteristics include plant size, dependence of product rate on product purity, minimum power consumption, costs of isotope separation, minimum time for reaching steady production, and effect of third component on process performance and product costs. The concepts of value functions, separative power, and separative work are used to derive the characteristics, and the analogy between isotope separation theory and thermodynamics is emphasized. (D.L.C.)

**32473** METHOD FOR THE ENRICHMENT OF DEUTERIUM BY CATALYTIC AIDED ISOTOPE EXCHANGE BETWEEN WATER AND HYDROGEN IN HOT-COLD-COLUMNS. Klaus Wetzel (to VEB Vakutronik). German Patent 1,145,145. Mar. 14, 1963 Filed Oct. 21, 1960.

In the method for the enrichment of deuterium by catalytic isotope exchange, the water and the hydrogen are circulated through the cold column in opposite directions and through the hot column in the same direction. (Gmelin Inst.)

# MATHEMATICS AND COMPUTERS

**32474** (IS-698) PROCESS SIMULATION ON A DIGITAL COMPUTER USING ANALOG METHODS. George J. Farris and Lawrence E. Burkhart (Ames Lab., Ames, Iowa). July 10, 1963. Contract W-7405-eng-82. 26p. (CONF-110-1)

For Presentation of Annual Meeting of the American Institute of Chemical Engineers, Houston, Texas, Dec. 1963.

A system was developed to program a digital computer in much the same manner as an analog computer is programmed. Properties of a general purpose analog computer and a digital differential analyzer were combined to yield a program which employs, as input, standard data cards prepared from a diagram analogous to an analog computer diagram. The capacity of the system is much greater than that of most analog computers, making it applicable to large simulation problems. No scaling is required. The system is compatible with the Fortran symbolic language and may be used as part of a larger digital computer program. It may be applied to the more general types of boundary value problems arising in process simulation in addition to the initial value problems ordinarily solved on analog computers. It is particularly well adapted to non-linear problems and to control problems involving large transport delays. The program operates in basic machine language and, when used by itself, requires no compilation time. (auth)

**32475** (SCR-641) A MATHEMATICAL MODEL FOR AN ASSOCIATIVE MEMORY. G. J. Simmons (Sandia Corp., Albuquerque, N. Mex.). Apr. 1963. Contract [AT(29-1)-789]. 98p.

A mathematical model for an associative memory is proposed that uses associative addressing and distributed storage. Associative addressing is accomplished by mapping from a space with relatively few dimensions (input variables) to the vertices of a binary-valued hypercube embedded in a much higher dimensional space. The dimension of the image space is chosen to be sufficiently great that a hyperplane can be passed through the origin such that the relative distances to the image points are the relative functional values that are to be stored. The distributed memory is achieved in the n-tuple representation of the hyperplane, since each element will in general be used in calculating the distance to many points (images), and hence in storing many functional values. A technique formulated for solving the large linear systems that arise in such a problem and a proof of the convergence of such a procedure are included. Unfortunately, the basic form of an associative memory imposes the restriction that only a single linear expression be available at any one time, and that further its relation to other expressions not be known. This generally imposes a further restriction that the linear expressions be randomly drawn from the linear system and returned. Typically these systems have many more variables than equations. Several examples of the behavior of the associative memory as simulated on a CDC 1604 computer and of the convergence properties of the algorithm proposed here to solve the associated linear systems are considered. (auth)

**32476** (UCRL-10927) UNFOLD—A COMPUTER PROGRAM FOR ANALYZING LINEAR SYSTEMS BY CALCULATION IN THE TIME DOMAIN. Mark W. Horovitz and Grove C. Nooney (California. Univ., Berkeley. Lawrence Radiation Lab.). July 1963. Contract W-7405-eng-48. 5p. (CONF-134-1)

For Presentation at Conference on Engineering in Medicine and Biology, Baltimore, Nov. 1963.

The integral equation $A(t) = \int_{-\infty}^{t} G(t - T)\, B(t)dT$ relates the input B(t) to the output A(t) in a linear time-invariant system. G(t) is a weighting function (impulse-response function), characterizing the response of the system. From given values of A(T) and B(T) at several values of t, program UNFOLD computes a G(T) that best fits the weighting function in a certain sense. Conversely, values of B(T) and G(T) can be used to compute A(T), UNFOLD proceeds by first expanding A(T), B(T), and G(T) in terms of a set of functions; G(t) is then obtained by a least-squares procedure. (auth)

**32477** (Y-1420) AN EXTENSION OF APT TO OBTAIN CENTROID AND INERTIA INFORMATION. A. H. Fowler and C. W. Wilson (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). May 21, 1963. Contract W-7405-eng-26. 29p.

Computer routines are described that can be used with the APT system to obtain centroids and inertias of plane surfaces and solids of revolution. (auth)

**32478** NEW CONCEPT OF REPRESENTATION OF A LIE ALGEBRA. A. Loinger (Università, Pavia, Italy and Istituto Nazionale di Fisica Nucleare, Milan). Ann. Phys. (N. Y.), 23: 23-7(July 1963).

A new, more general, concept of operator representation of a Lie algebra, which has emerged from a group-theoretical study of classical mechanics, is investigated in detail on the example of the three-dimensional homogeneous rotation group. (auth)

**32479** EXPANSIONS ASSOCIATED WITH A PAIR OF SINGULAR FIRST-ORDER DIFFERENTIAL EQUATIONS. B. W. Roos and W. C. Sangren (General Atomic Div., General Dynamics Corp., San Diego, Calif.). J. Math. Phys. (N. Y.), 4: 999-1008(Aug. 1963).

A study of the spectral properties of a Dirac operator is continued. The analytical methods developed by Weyl and Titchmarsh for the analysis of the Sturm–Liouville equation are extended to the investigation of a system of two singular first-order differential equations. Expansions associated with the system are established and a convergence theorem is presented. (auth)

**32480** RANDOM MATRIX DIAGONALIZATION—SOME NUMERICAL COMPUTATIONS. C. E. Porter (Brookhaven National Lab., Upton, N. Y.). J. Math. Phys. (N. Y.), 4: 1039-42(Aug. 1963). (BNL-6763)

Numerical results of Monte-Carlo calculations of spacing and eigenvalue distributions for the invariant and independent Gaussian orthogonal ensemble of hamiltonian matrices are presented. Many of the histograms should be used for comparison with experimental data. A table of the first few moments of each distribution is given. For the spacing distributions, such moments are equivalent to spacing correlation coefficients, and hence these are also made available indirectly. (auth)

**32481** A REPORT ON THE COMPUTER ACTIVITIES OF THE BETA- AND GAMMA-RAY SPECTROSCOPY GROUP AT LOUISIANA STATE UNIVERSITY. Roy A. Parker, Charles L. Peacock, Jr., and Max Goodrich (Louisiana State Univ., Baton Rouge). 33p. (CONF-13-1)

From American Physical Society Meeting, Houston, Tex., Feb.-Mar. 1963.

Digital computer analyses of Fermi-Kurie plots of beta spectra, and of data from multi-channel gamma-spectrum analyzers, are reviewed and described. (T.F.H.)

# METALS, CERAMICS, AND OTHER MATERIALS

## General and Miscellaneous

*Refer also to abstracts 31798, 32822, and 33393.*

**32482** (AD-408618) COMPOSITE MATERIALS: AN ANNOTATED BIBLIOGRAPHY. SUPPLEMENT I. Helen M. Abbott, comp. (Lockheed Missiles & Space Co., Sunnyvale, Calif.). June 1963. 53p. (SB-63-49)

Supplement to Lockheed Missiles & Space Co. Report SB-62-58.

An annotated bibliography containing 90 selected references pertaining to composite materials is presented. These references were selected as supplement material to a previous report; COMPOSITE MATERIALS: AN ANNOTATED BIBLIOGRAPHY, Helen M. Abbott, Lockheed Missiles & Space Company SB-62-58, February 1963. This search covered the period from September 1962 to June 1963. (auth)

**32483** (BMI-X-10027) DEVELOPMENT OF URANIUM MONONITRIDE. Quarterly Progress Report, October–December 1962. Donald L. Keller (Battelle Memorial Inst., Columbus, Ohio). Jan. 1, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract W-7405-eng-92. 10p. (EURAEC-10027)

The thermal diffusivity of UN was measured to obtain thermal conductivity above 1000°C. In these tests a small specimen is given a pulse of heat with a laser. Initial results show good agreement with thermal conductivity values obtained by a longitudinal heat-flow method. At high temperature, surface oxidation of the UN causes a large drop in thermal diffusivity. Studies on melting and casting of UN have centered around developing consumable-electrode procedures. Minor additions of iron, nickel, and perhaps niobium have improved the quality of consumable-electrode-melted UN by reducing the amount of voids and high nitride accumulations. Effects of arc distance and arc voltage, specimen diameter, and hearth geometry on the quality of melted and cast UN were studied. The equilibrium nitrogen pressure at 800°C was determined for a series of compositions between $U_2N_3$ and $UN_2$. On the basis of variations in nitrogen pressure with compositions it is concluded that a solid-solution region exists between $U_2N_3$ and $UN_2$. (N.W.R.)

**32484** (GEAP-4284) SPECIFIC ZIRCONIUM ALLOY DESIGN PROGRAM. Quarterly Progress Report No. 5, April–June 1963. H. H. Klepfer, J. L. Jaech, R. E. Blood, and D. L. Douglass (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). July 1, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 71p. (EURAEC-754)

Thirty-one alloys selected for study of corrosion rate, hydriding rate, and hydrogen embrittlement are in test. The corrosion testing of 1800 coupons to 3000 hours at 300, 400, and 500°C in refreshed steam was completed. Statistical data analysis of the corrosion results are reported and alloys showing better corrosion performance at all test temperatures than that for Zircaloy-2 are discussed. Preliminary data for hydrogen uptake after long exposures at 400 and 500°C are presented; the uptake for the alloys showing the best corrosion performance is discussed. Post-corrosion mechanical property measurements are also reported along with the preliminary results of x-ray diffraction and metallographic studies relating to hydrogen embrittlement. A wide variation in resistance to embrittlement at a given hydrogen level was observed and can be tentatively correlated with original ductility, crystallographic texture, and hydride platelet orientation. Studies concerning the mechanism of corrosion and hydriding in zirconium alloy are also reported. The results of recent neutron activation analyses of stripped corrosion films are presented. Oxygen diffusion through doped nonstoichiometric $ZrO_2$ is now proceeding following earlier difficulties in sample preparation. (auth)

**32485** (MAB-193-M) BERYLLIUM IN AEROSPACE STRUCTURES. (National Research Council. Materials Advisory Board). July 1, 1963. 24p.

The status of structural beryllium is reviewed. Specific studies were made of the use of beryllium in aircraft and space vehicle structures. Applications, brittleness, structural testing, economic justification, and AEC beryllium utilization are discussed. (M.C.G.)

**32486** (NCSC-2663-13) URANIUM INTERSTITIAL PHASES. Quarterly Report. Robert F. Stoops and John V. Hamme (North Carolina State Coll., Raleigh). June 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(40-1)-2663. 14p. (EURAEC-766)

Approximately 130 grams of $U(C_{0.75}O_{0.25})$ were made, and some of this material was used in sintering experiments to produce specimens for the further evaluation of physical properties. None of the sintered specimens had densities greater than 71.4% of the theoretical value for $U(C_{0.75}O_{0.25})$. The highest density (9.8 g/cc) was obtained by sintering a cold-pressed specimen for forty minutes at 2000°C under a CO pressure of 2.35 mm Hg. Chemical analyses and x-ray-diffraction analyses have confirmed further the existence of the U(C,O) phase and its maximum oxygen content of 12.5 atomic percent. Nitrogen appears to be more reactive with $U(C_{0.75}O_{0.25})$ than with UC at 1450°C and approximately 0.25 atmospheres of nitrogen partial pressure; however, further experimentation is needed to confirm this. (auth)

**32487** (NCSC-2981-4) A NUCLEAR FUEL CONSISTING OF VERY SMALL UNIFORMLY DISPERSED UC PARTICLES IN A URANIUM MATRIX. Quarterly Report. Robert F. Stoops and Anthony J. Mione (North Carolina State Coll., Raleigh). June 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(40-1)-2981. 14p. (EURAEC-765)

Specimens prepared by the cold-pressing and sintering technique were very porous, but specimens with only 3% porosity were produced by hot pressing. Time and temperature must be very carefully controlled during hot pressing to prevent undesirable grain growth. The degree to which the individual UC particles are surrounded by a film of uranium metal was not determined, but electron microscopic techniques will be used for this purpose in the future. X-ray-diffraction analyses of powder batches revealed that they had become contaminated with oxygen in the form of $UO_2$ during milling, and it was found that the $UH_3$ was oxidizing preferentially. Oxygen contamination was drastically reduced by milling the UC powder separately and then dry blending the milled carbide powder with the $UH_3$ in argon. Evaluation of sintered and hot pressed

specimens is complicated by oxide contamination. Since suitable standards are not available for quantitative x-ray-diffraction analysis of the phases present in sintered specimens, metallographic point-counting will be used for this purpose and for porosity determination. (auth)

**32488** (TID-19057) MATERIALS FOR HIGH TEMPERATURE NUCLEAR ENGINEERING APPLICATIONS. Summary Report No. 2, July 1, 1962 to June 1, 1963. J. D. Fleming, J. W. Johnson, Paul Boland, and S. H. Bomar (Georgia Inst. of Tech., Atlanta. Engineering Experiment Station). June 1, 1963. Contract AT(40-)-2483. 65p.

The compressive strength, bulk density, and porosity of slip-cast fused silica were measured as a function of firing conditions under air and steam conditions. Methods were developed for the determination of several activation energies characterizing transport processes in the firing of slip-cast fused silica. Analysis of the early devitrification process during firing of slip-cast fused silica indicated that the cristobalite content should vary with the cube of firing time. A study was made of the influences of pressure application and mold vibration on casting of fused silica slip. A statistical study was made of the effects of 0.1 and 1 wt % additions of Baymal on the reaction characteristics of $Al-U_3O_8$ composites. The effects of $U_3O_8$ particle size were studied in $Al-U_3O_8$ composites. One differential thermal analysis furnace was converted to chromel–alumel thermocouples to give increased sensitivity. Differential thermal analysis was applied to these pellets using various standards. Metallographic examination of fired ATR specimens was begun. Rough determinations were made of the load-bearing capability of ATR composites at elevated temperatures. A high-temperature x-ray-diffraction system was constructed to permit investigation of $Al-U_3O_8$ reaction kinetics. Initial studies were made to compare reactions in cold-pressed $Al-U_3O_8$ pellets with those of cold pressed $Al-UO_2$ pellets. (N.W.R.)

**32489** DIRECT OBSERVATION OF THE NUCLEATION OF CRYSTALLITES BY ELECTRON BEAM HEATING IN AMORPHOUS Nb FILMS. T. E. Hutchinson (Minnesota Mining and Mfg. Co., St. Paul). Appl. Phys. Letters, 3: 51-2(Aug. 15, 1963).

Thin films of niobium formed on cleaved rock salt substrates are observed using the electron microscope in an effort to understand nucleation and growth in thin films. (R.E.U.)

**32490** THE METALLURGY OF URANIUM. Friedrich Hochstetter. Chemiker-Ztg., 86: 317-18(May 5, 1962). (In German)

A review of U metallurgy is presented in terms of U ores and deposits, ore dressing and beneficiation by leaching; extraction of the intermediate products $U_3O_8$ and $UCl_4$; and extraction of U metal by reduction processes using metals, C and Hy as reducing agents, by decomposition of U halides or hydrides, and by fused salt electrolysis. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32491** BERYLLIA CERAMICS. P. G. Taylor and I. J. Holland. Eng. Materials and Design, 5: 646-9(Sept. 1962).

A review is presented on the production techniques, physical, mechanical, and nuclear properties, thermal shock resistance, chemical reactivity and applications in nuclear energy, refractory wares, and electronics of hot-pressed and slip-cast BeO. (Rev. Metal Lit., 20: No. 1, Jan. 1963)

**32492** REDUCTION OF COLUMBIUM CONCENTRATES BY CARBON. N. P. Lyakishev and V. A. Boglyubov. Izv. Vysshikh Uchebn. Zavedenii, Chernaya Met., 5: 70-7(Jan. 1962). (In Russian)

The influence of Fe, Si, and C content and temperature on the reduction of Nb concentrates and Nb–Fe–Si alloys and on the physical and chemical properties of the slag was investigated. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32493** NEUTRON ABSORBING MATERIALS FOR REACTOR CONTROL. B. Schallopp. Kerntechnik, 5: 257-65 (June 1963). (In German)

With regard to the necessity of a certain negative reactivity, the relation between location and surface area of "black" absorbers is outlined. The nuclear properties important for absorbing materials are discussed in detail. A description of the peculiarities of the different absorbing materials, i.e., fabricability, corrosion, temperature effects, etc., helps to explain the possibilities of technical application. Finally, some problems concerning the design of absorbing elements are indicated. (auth)

**32494** NEW BERYLLIUM IS ONE-THIRD STRONGER. Mater. Design Eng., 58: No. 2, 94(Aug. 1963).

A new grade of Be (I-400) was developed with a high strength-weight ratio (superior to H-11 steel and an all-beta Ti alloy between room temperature and 1100°F) which makes it attractive for aerospace structures and pressure vessels. Also, the Be offers high stiffness-weight ratios. I-400 differs from other grades of Be in having a finer grain size and a high BeO content. (R.E.U.)

**32495** NIOBIUM–TANTALUM ALLOYS FOR IMPREGNATION. K. Kieffer, St. Windisch, and H. Nowotny (Universität, Vienna). Metall, 17: 669-77(July 1963). (In German)

The historical development of impregnated alloys and the various applicable technical processes are described. Their properties are discussed on the basis of the properties of W–Cu, W–Ag, W–U, Nb–U, and Ta–U impregnated alloys. Investigations of Ta–Cu, Ta–Ag, Nb–Cu, and Nb–Ag impregnated alloys are described, and results on density, electric conductivity, hardness, structure, and phase composition are reported on the basis of x-ray studies. Preliminary results are presented for Ta–Ni–Cu and Nb–Ni–Cu alloys. (tr-auth)

**32496** THE PROPERTIES OF WELDS OF NIOBIUM-CONTAINING ZIRCONIUM ALLOYS. H. Richter and J. H. Tverberg (Metallgesellschaft AG, Frankfurt am Main). Metall, 17: 678-84(July 1963). (In German)

Niobium-containing zirconium alloys can be welded by the argon-arc and the electron-beam methods. The weld seams exhibit, in the welded state, an increased corrosion in water and steam in comparison with the nonwelded starting material, which is reduced by cooling of the welding temperature. By an additional annealing of the weld, the corrosion behavior of the weld is improved. The strength and yield point of the welds are in each case higher than the corresponding values for the starting material. (tr-auth)

**32497** A NEW TECHNIQUE: SINTERING. M. Bourzes. Metallurgie (Paris), 94: 363, 365, 367, 369, 371-2(Apr. 1962). (In French)

Bronze, Fe, mild steel, alloy steel, brass, U, Si, Sn, W, stainless steel, Fe alloy, Fe–Cu alloy, Cu alloy, Ni–Ag alloy, and mixtures of Cr–C–Ni, Ti–C–Co–Ni–Cr, and Cr–B, Zr–B, and Ti–B, with Cr or Mo were produced for machine components and automobile lubricant bearings with specified physical and mechanical properties, corrosion resistance, and structure. (TCO)

**32498** MATERIALS FOR ION PROPULSION. H. Todd, F. Barcatta, D. Clark, and R. Worlock. Metals Eng. Quart., 2: 9-16(Aug. 1962).

A review is presented on problems of material requirements, such as high operating temperatures, low pressures, presence of Cs vapor, necessity for high ionization efficiencies, and low electrode sputtering rates, in ion propulsion devices. Other problems include metal joining of porous ionizing material and the Cs box, lack of infiltration of the porous ionizing surface, high-temperature strength, and Cs compatibility. (TCO)

**32499** ELECTROREFINING OF NUCLEAR METALS IN A MOLTEN SALT BATH. G. Chauvin, H. Coriou, and J. Hure. Metaux (Corrosion-Ind.), 37: 112-26(Mar. 1962). (In French)

The industrial electrorefining of commercial U, Be, Pu, Th, and Ti by chloride and fluoride salt electrolytic baths was investigated. The influence of humidity and concentration of electrolyte on the resulting purity was determined. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**32500** STUDIES OF Al–U ALLOYS. Noritsugu Mitamura (Mitsubishi Atomic Power Ind., Inc., [Japan]); Kazuo Maruya, and Jôtarô Kimura. Nippon Genshiryoku Gakkaishi, 5: 467-75(June 1963). (In Japanese)

Al–U alloy is one of the typical dispersion fuels which are now being used in high-performance research reactors. Due to a large fraction of intermetallic compound, Al–U alloy containing upwards of 40 wt % U is inherently brittle and difficult to fabricate. This study was aimed at finding out basic requirements in manufacturing Al–U fuel materials. Several melting procedures were tried. Microstructures of castings and the effect of some additives to them, that is, a complete suppression of formation of equilibrium compound $UAl_4$ in 45 wt % U–Al alloy, were investigated by using optical- and electron-microscopes and an x-ray diffractometer. As another procedure to make a homogeneous Al–U alloy ingot, reduction of $UF_4$ with pure molten aluminum was successful with a good yield of better than 94%. Diffusion coefficient measurements of uranium in molten aluminum gave the following equation: $\log D\ (cm^2/sec^{-1}) = -3{,}450 + (-0.103 \times 10^4/T)$. Because of the small diffusion coefficient of uranium, the reduction process with aluminum was considered superior than ordinary melting process in fabricating these alloys containing downward of 30 wt % U. (auth)

**32501** THORIA-DISPERSED NICKEL NEW ALLOY FOR HOT JOBS. Herbert Kee. Prod. Eng., 33: 58-9 (Aug. 20, 1962).

A comparison was made of thoria dispersed Ni with Haynes 25 alloy, SM 302, Hastelloy X, and René 41 in terms of oxidation and corrosion resistance, stress rupture strength, rupture life, and high temperature tensile strength. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**32502** ZONE REFINING OF ALUMINUM. H. G. Bratsberg, D. Foss, and O. H. Herbjoernsen (Univ. of Oslo). Rev. Sci. Inst., 34: 777-8(July 1963).

The procedure of zone refining Super Purity Al is described. The impurity content was studied by neutron activation and spectrographical means, and the ratio $R_{293°K}/R_{4.2°K}$ was measured. The purest material has a resistance ratio of 26,500 in bulk. (auth)

**32503** ZIRCONIUM, A NEW CONSTRUCTURAL MATERIAL. Technica, 11: 763-4(May 11, 1962). (In German)

A review of the physical properties, including absorption cross section, thermal and electric properties, mechanical strength, and corrosion resistance of Zr and Zircaloy-2 is presented. Consideration is also given to various processing techniques including vacuum arc melting and welding and technical application in nuclear engineering and medical apparatus. (Rev. Metal Lit., 19: No. 8, Aug. 1962)

**32504** THE PRODUCTION OF REACTIVE METALS—RETROSPECT AND PROSPECT. L. M. Pidgeon (Univ. of Toronto). Trans. AIME, 227: 821-34(Aug. 1963).

The reactive metals are above manganese on the electromotive series. Their compounds are characterized by large heats of formation and they cannot be reduced from their ores by classical methods. Three general production methods are used: (a) fused salt electrolysis; (b) reduction of a halide by another metal; and (c) reduction of the oxide by another metal. Method (a) is highly developed, as in the case of aluminum, (b) in the case of titanium, and (c) is successful in the case of volatile metals such as magnesium and calcium. (auth)

**32505** METALLOGRAPHIC ETCHING BY MONOENERGETIC ION BOMBARDMENT. P. S. Maiya and J. B. Newkirk (Cornell Univ., Ithaca, N. Y.). Trans. Am. Soc. Metals, 55: 474-82(Sept. 1962).

A method is described by which ions of an inert gas are drawn from a slot in a small ionization chamber and then are accelerated through a controllable and constant potential difference to the specimen. The kinetic energy of the ions is transferred to surface atoms of the specimen, resulting in selective removal of the less tightly bound atoms. Since all of the ions fall through the same potential difference the beam is monoenergetic. This feature may allow threshold binding energies of surface atoms to be determined experimentally. Other features of the method are: (1) the etching potential can be varied down to 0 volts since it is not necessary to maintain a glow at the cathode; (2) operating pressures well below those normally used in ion bombardment etching are possible for the same reason; (3) etching time depends upon the beam density and energy; it is typically 1 to 2 hr; (4) the specimen is only slightly heated during etching. Further evaluation of the method is in progress. (auth)

**32506** HIGH MELTING-POINT GLASSES CONTAINING URANIUM OXIDE. G. Tuite, N. Rawson, and M. S. R. Heynes (A.E.I. Research Lab., Rugby, Eng.). Trans. Brit. Ceram. Soc., 62: 289-304(1963).

A wide range of alumino-silicate glass compositions was investigated in which it is possible to dissolve 20 to 25% of $UO_2$ at the temperatures at which the glasses have been melted (1700 to 1800°C). $UO_2$ will dissolve in the glass only when the melting atmosphere is oxidizing. In a homogeneous glass containing dissolved $UO_2$, it is possible to bring the $UO_2$ out of solution again in a controlled manner by heat treatment in a neutral or reducing atmosphere. The resulting material consists of a dispersion of $UO_2$ particles up to 5-$\mu$ dia dispersed in a partly glassy, partly crystalline matrix. (auth)

**32507** DEPOSITION OF ZIRCONIUM COATINGS FROM THE VAPOUR OF THE IODIDES. L. W. Owen and L. Fairman. Trans. Inst. Metal Finishing, 39: 98-103(1962).

A review is given on techniques for deposition of Zr coatings with data on equipment and procedures using thermal decomposition of the iodides. The effects of specimen temperature, Zr sponge temperature, and iodine vapor pressure on the deposition rate were investigated. Comparison was made of the coatings on Mo and stainless specimens with consideration to the problem of interdiffusion of Zr and steel or stainless steel. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**32508** COLUMBIUM AND TANTALUM. Usine Nouvelle, 103; 105; 107-13; 115-17: 119: 121(Apr. 1962). (In French)

A review is presented on the extraction of pure Nb and Ta from oxide ores by chemical and physical processes; determination of their crystalline, chemical, mechanical, thermal, electric, and magnetic properties; and composition, mechanical properties, and corrosion resistance of alloys and steels containing Nb. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**32509** DEVELOPMENT OF NICKEL ALLOY SURFACING TECHNIQUES FOR FEEDWATER HEATERS. S. D. Reynolds, Jr., W. L. Spahr, and L. K. Poole (Westinghouse Electric Corp., Lester, Penna.). Welding J. (N. Y.), 42: 635-43(Aug. 1963).

A Ni barrier layer on carbon steel with a Cu–Ni or Ni–Cu top layer deposited by an automatic linear horizontal constant-velocity oscillated gas-shielded-arc process is proposed for tube-to-tube sheet welds in high pressure feedwater heaters. The proposed method forms a transition from the metallurgical, mechanical, and physical properties of carbon steel to those of the tubing material. It also minimizes corrosion, increases erosion resistance, and supplies a high level of deoxidizers to permit the tube-to-tube sheet welds to be made by a simple fusion process. Although the process was developed with tube-to-tube sheet welding in mind, it is a superior method for depositing corrosion resistant Cu–Ni or Ni–Cu overlays. (P.C.H.)

**32510** ELECTRODEPOSITION OF ALLOYS. PRINCIPLES AND PRACTICE. VOLUME I. Abner Brenner. New York, Academic Press, 1963. 732p. $24.00.

A general survey of electrodeposition, its principles, and alloys of Cu and Al are presented. Attempts were made to establish a philosophy of alloy plating. The alloy plating systems are grouped into five types, and each is individually discussed with respect to the plating variables. The fundamental bases of alloy deposition are summed up in six principles. The role of diffusion in alloy deposition is also treated thoroughly. The role of the current density versus potential relations in alloy deposition was examined objectively, and certain misconceptions regarding their value in alloy deposition are pointed out. (P.C.H.)

**32511** ELECTRODEPOSITION OF ALLOYS. PRINCIPLES AND PRACTICE. VOLUME II. Abner Brenner. New York, Academic Press, 1963. 672p. $22.00.

Practical and specific information on the electrodeposition of alloys is presented. Topics discussed include: electrodeposition of Cd, Pb, Sn, Zn, Cr, In, Tl, and Mn alloys and some of the less noble metals; electrodeposition of the iron-group metals, with special reference to anomalous codeposition; induced codeposition of alloys containing W, Mo, Ge, or P; and electrodeposition of alloys of metals more noble than hydrogen. (P.C.H.)

**32512** SPECIAL METALLURGY. Vol. 3. ZIRCONIUM AND ITS ALLOYS. Jean Herenguel. Paris, Presses Universitaires de France, 1962. 185p. (In French)

A review of the production, transformation, and properties of Zr and its alloys is presented. Topics include electrolytic extraction and Kroll process reduction of zircon and baddeleyite ores and induction and arc melting, precision, pressure, skull-process, continuous, crucible, and gravity casting; forging; sinter and shock extrusion; hot and cold rolling; swaging; heat treatment; drawing and wire drawing; bending; forming; flanging; mechanical machining; pickling, brightening; mechanical joining; inert arc, resistance, and pressure welding; brazing; Ni and Fe electrodepositing; anodic oxidation, enameling, phosphatizing, and nitride and carbide depositing. Data are given on mechanical and physical properties and industrial application. (Rev. Metal Lit., 19: No. 11, Nov. 1962)

**32513** FUTURE AIR FORCE MATERIALS REQUIREMENTS FOR AEROSPACE PROGRAMS. L. R. Standifer (Air Force Systems Command, Wright-Patterson AFB, Ohio). 11p. (CONF-94-3)

From American Nuclear Society Meeting, Nuclear Materials for Space Applications, Cincinnati, Apr. 1963.

A brief review is presented of the materials program of the Air Force Materials Laboratory in the nuclear area and other major technical areas. (D.L.C.)

**32514** PROCESS FOR THE EXTRACTION OF RELATIVELY PURE TITANIUM AND OF RELATIVELY PURE ZIRCONIUM AND HAFNIUM. Guy Ervin, Jr. and Herbert F. G. Ueltz (to Norton Co.). U. S. Patent 3,098,805. July 23, 1963. Filed June 25, 1959.

A process for producing relatively pure Ti, Hf, or Zr metal is based on electrolytic deposition of metal in an electrolytic cell having a consumable anode made of carbide of the metal. The electrolytic bath is composed of fused salt, which is the halide of a metal selected from the group consisting of the alkali metals and alkaline earth metals including Mg and mixtures of such halides. Addition of a small amount of double halide of alkali metal and the metal in question accelerates the process, produces purer metal, and makes larger crystals. The temperature of the bath should be over 800°C, preferably 850°C. An apparatus in which the process can be carried out is illustrated, and examples of the process are given. (A.G.W.)

**32515** METHOD FOR PREPARATION OF SINTERABLE BERYLLIUM OXIDE. Bernard J. Sturm (to U. S. Atomic Energy Commission). U. S. Patent 3,100,686. Aug. 13, 1963.

High-purity beryllium oxide for nuclear reactor applications can be prepared by precipitation of beryllium oxalate monohydrate from aqueous solution at a temperature above 50°C and subsequent calcination of the precipitate. Improved purification with respect to metallic impurities is obtained, and the product beryllium oxide sinters reproducibly to a high density. (AEC)

## Corrosion

**32516** (DPSPU-62-30-26) STRESS CORROSION CRACKING OF TYPE 304 STAINLESS STEEL IN HIGH-PURITY HEAVY WATER. S. P. Rideout (Du Pont de Nemours (E. I.) & Co. Savannah River Plant, Aiken, S. C.). Mar. 1963. Contract AT(07-2)-1. 36p. (CONF-28-5)

From Second International Congress on Metallic Corrosion, New York, New York, Mar. 1963.

Intergranular stress corrosion cracking caused failure of two Type-304 stainless-steel outlet nozzles in high-purity heavy-water moderator service in nuclear reactors. The failure cracks propagated from intergranular pickling damage to the ½-inch-thick steel, which was sensitized during initial fabrication. Nuclear radiation damage was not a factor. Laboratory tests duplicated plant experience and demonstrated that Type-304 stainless steel which was sensitized and pickled in the commonly used $HNO_3$:HF acid is extremely susceptible to stress corrosion cracking in water with a very low concentration of chloride ion. Tests results are described. (auth)

**32517** (RFP-307) CORROSION STUDIES ON 304 STAINLESS STEEL CONTAINING ONE PERCENT BORON-

10. F. E. Butler (Dow Chemical Co. Rocky Flats Div., Golden, Colo.). July 19, 1963. Contract AT(29-1)-1106. 11p.

A 1% boron-10 alloy of 304L stainless steel appeared to be a satisfactory material for use in 7N $HNO_3$–0.1N HF solutions when the free fluoride was complexed with 2.5:1 atomic ratio aluminum ion. Selective dissolution of boron is a factor which should be considered when sizing criticality control grids. The alloy was found to be resistant to 0.35 and 7N nitric acid, but substantial corrosion rates were observed when the coupons were exposed to 7N nitric acid, 0.1N in fluoride. The corrosion rate was increased one and one-half times for each 10°C increase in temperature. (auth)

**32518** (Y-1417) STRESS CORROSION CRACKING IN URANIUM–MOLYBDENUM ALLOYS. J. W. Pridgeon (Union Carbide Nuclear Co. Y-12 Plant, Oak Ridge, Tenn.). Aug. 12, 1963. Contract W-7405-eng-26. 90p.

An investigation was conducted to determine the cause of cracking, during tension, on the surface of tensile specimens of U–Mo alloys. The cracking was observed in alloys that were water quenched from a temperature range in which the body-centered cubic γ phase was stable and, subsequently, stressed in tension. The investigation was carried out on alloys of U–Mo containing 5 and 4 wt % Mo. It was discovered early in the study that the cracking could be eliminated by testing tensile specimens in a He atmosphere. Because of this result, tensile tests were performed in vacuum, $O_2$, impure $N_2$, and purified $N_2$. Additional experiments were done to establish the relation of stress state, temperature, strain rate, $O_2$ pressure, stress magnitude, and grain size to the cracking phenomenon. U–4 wt % Mo and U–5 wt % Mo were compared with respect to microstructure and crystal structure, since both alloys cracked during the tensile test. The origin and propagation of cracks in the microstructure were studied, using motion pictures and metallography. The results of the various experiments showed that the cracking occurred only in tension and was caused by stress-corrosion cracking due to the presence of $O_2$ in the atmosphere. The rate of cracking increased as the temperature was increased above 25°C. Below 10°C cracking was not observed in the U–5 wt % Mo alloy. Cracking was not associated with just one metastable phase, since it was observed in both the U–5 wt % Mo and U–4 wt % Mo alloys, which have different crystal structures when rendered metastable by water quenching from the γ phase field. The path of fracture was transgranular and was not associated with deformation markings in the grains. (auth)

**32519** HYDROGEN UPTAKE OF ZIRCONIUM ALLOYS DURING WATER AND STEAM CORROSION. H. H. Klepfer (General Electric Co., Pleasanton, Calif.). Corrosion, 19: 285t-91t(Aug. 1963).

Corrosion H weight gains were studied for four Zr-base binary systems: Zr–Fe, Zr–Cr, Zr–V, and Zr–Sb. Data on twenty compositions for exposures of up to 3000 hr in $H_2O$ at 360°C and in steam at 400 and 482°C showed three alloys exhibiting less H weight gain than by Zircaloy-2. The various intermetallic phases in the alloys did not play a consistent role in determining the percentage corrosion H taken up by the alloys. Proportion of corrosion H passing through the corrosion films varied from 0.4 to 100%, depending on alloy composition; it varied with film thickness for most alloys. It is proposed that H uptake in Zr alloys is determined by two competing processes of charge transport through the oxide film. (auth)

**32520** INFLUENCE OF ENVIRONMENT ON THE CORROSION OF ZIRCONIUM AND ITS ALLOYS IN HIGH-TEMPERATURE STEAM. J. N. Wanklyn, C. F. Britton, D. R. Silvester, and N. J. M. Wilkins (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Electrochem. Soc., 110: 856-66(Aug. 1963).

Measurements of weight gains and film capacities of Zr and Zr alloys in steam and O at atmospheric and high pressures are reported. At best, the behavior of resistant alloys and of Van Arkel Zr in steam inhibited with boric acid is comparable to that of Van Arkel Zr in O. It was concluded that in steam, but not in O, the pressure drop due to the flow of gas through porous oxide is a significant factor in the effects observed. Alloying elements, and also boric acid inhibition, decrease the film cracking or porosity, which, with unalloyed Zr, leads to very rapid corrosion in high-pressure steam. With some more resistant materials there appears to be a compensation effect whereby films formed in high-pressure steam are less porous than those formed at atmospheric pressure. Detailed topographical studies of the early stages of film growth and breakdown on Van Arkel Zr in steam and in O are described. In addition to uniform film growth, at rates varying with grain orientation, rapid localized attack is found in steam. Such attack is accelerated by an increase of pressure and appears to be diminished by additions of Cu and by boric acid inhibition. The localized corrosion is considered to be due to the same type of film failure as is responsible for cracking or porosity in thicker, more uniform, films at a later stage of corrosion. The implications of the findings for the development of steam-resistant alloys are considered. (auth)

**32521** A STUDY OF EMBRITTLEMENT OF HIGH STRENGTH STEELS BY HYDROGEN ISOTOPES. I. TESTING OF STEEL RINGS AS SPECIMENS, A COMPARISON OF HYDROGEN AND DEUTERIUM EMBRITTLEMENT, AND PERMEATION STUDIES. Gwendolyn B. Wood (National Bureau of Standards, Washington, D. C.). J. Electrochem. Soc., 110: 867-77(Aug. 1963).

Embrittlement of steel produced from electrolytic charging in $H_2O$ and $D_2O$ solutions is discussed. A comparison of the retention of embrittlement with retained gas content in uncoated steel is given. The separation factor for the electrodeposition of hydrogen and deuterium on SAE 4130 steel was found to be 5.9. Permeation of the mixture of these isotopes through steel results in further enrichment with respect to hydrogen. The diffusion coefficients and permeation rates for hydrogen and deuterium in steel are compared. (auth)

**32522** A STUDY OF EMBRITTLEMENT OF HIGH STRENGTH STEELS BY HYDROGEN ISOTOPES. II. A COMPARISON OF GAS CONTENTS AND HYDROGEN OR DEUTERIUM EMBRITTLEMENT RESULTING FROM ELECTROPLATING PROCESSES. Gwendolyn B. Wood (National Bureau of Standards, Washington, D. C.). J. Electrochem. Soc., 110: 877-85(Aug. 1963).

Plating processes introduce more deuterium into steel from heavy water solutions than hydrogen from ordinary water solutions, yet hydrogen embrittles steel more than deuterium. No simple relation between the total gas content and embrittlement was found. Embrittlement appears to be dependent on factors other than the total gas content. The difference in the chemical affinity of steel for hydrogen and deuterium is discussed. (P.C.H.)

**32523** OXIDATION OF BORON CARBIDE BY AIR, WATER, AND AIR-WATER MIXTURES AT ELEVATED TEMPERATURES. Lawrence M. Litz and R. A. Mercuri (Union Carbide Corp., Parma, Ohio). J. Electrochem. Soc., 110: 921-5(Aug. 1963).

A study of the oxidation of boron carbide powder showed measurable reactions at temperatures as low as 250°C with $H_2O$ vapor and 450°C in dry air. Removal of the $B_2O_3$ oxidation product by $H_2O$ vapor occurs at a rate in excess of the oxidation rate below 550 to 600°C. The presence of $B_2O_3$ on the $B_4C$ surface was found to inhibit the oxidation by $H_2O$ but not by air. Linear dependence of rate on the partial pressure of $H_2O$ was observed. The activation energy for the $H_2O-B_4C$ reaction was 11 kcal/mole/°C while that for the air$-B_4C$ reaction was 45 kcal/mole. Oxidation by dry air occurs at a lower rate than with $H_2O$ vapor until approximately 700°C (for 235 mm $H_2O$ partial pressure). (auth)

**32524** ZIRCONIUM–NIOBIUM BINARY ALLOYS FOR BOILING WATER REACTOR SERVICE. PART I. CORROSION RESISTANCE. H. H. Klepfer (General Electric Co., Pleasanton, Calif.). J. Nucl. Mater., 9: 65-76(June 1963). (In English)

The effects of heat treatment, corrosion temperature, and corrosion environment on the corrosion performance of sponge base Zr–Nb binary alloys containing up to 4.2 wt % Nb were studied. Beta treatments were found detrimental to corrosion resistance. Maximum corrosion resistance was found in samples heat treated to produce the equilibrium Nb content in the matrix at the test temperature. Two-phase alloys given the optimum heat treatment showed higher corrosion rates than Zircaloy-2 at 288, 360, and 400°C in static water and steam. At 482°C the Nb binaries performed better than Zircaloy-2. The alloys were very sensitive to N contamination in a simulated boiling water reactor environment at 288°C. At higher test temperatures N contents as high as 170 ppm did not adversely affect corrosion resistance. The sensitivity to heat treatment and to N contamination makes application in boiling water reactor environments doubtful. (auth)

**32525** ZIRCONIUM–NIOBIUM BINARY ALLOYS FOR BOILING WATER REACTOR SERVICE. PART II. CORROSION HYDROGEN EMBRITTLEMENT. H. H. Klepfer (General Electric Co., Pleasanton, Calif.). J. Nucl. Mater., 9: 77-84(June 1963). (In English)

Embrittlement by H produced during corrosion of sponge-base, Zr–Ni binary alloys containing up to 4.2 wt % Nb was studied. Thin corrosion films in $H_2O$ and in steam were found to allow the passage of about 12% of the corrosion-produced H into the underlying metal; beta-quenched samples continued to show low pickup through thick oxide films, at least up to 454 mg/dm$^2$, in steam. Alpha-treated samples in steam showed about 25% pickup through thick films. Total H weight gains were equal to or less than those for Zircaloy-2 in all tests. Hydrogen solubility was apparently higher in the Zr–Nb alloys than in Zircaloy-2. Mechanical tests revealed a low susceptibility to corrosion H embrittlement in alpha-treated Zr–Nb alloys. Corrosion performance of the binaries in a simulated boiling water reactor environment was found to be poor, however. Average hydriding rates in higher order alloys containing further additions of Fe, Cr, and Sb were not lower than those for the corresponding Zr–Nb binaries. (auth)

**32526** PROTECTION OF REFRACTORY METALS. E. S. Bartlett. Machine Design, 34: 198-200; 202; 204; 207-208; 210; 212(June 21, 1962).

A review of coating techniques for protecting Nb, Ta, Mo, and W at high temperatures is presented. Consideration is given to various coating materials and their effect on substrate under compression, high temperature, and an oxidizing environment. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**32527** OXIDATION RATE OF INTENTIONALLY PUNCTURED DUMMY FUEL ELEMENT. STUDY ON THE BEHAVIOR OF PUNCTURED FUEL ELEMENT FOR CALDER HALL TYPE REACTOR, (2). Kiyoaki Taketani and Katsuichi Ikawa (Japan Atomic Energy Research Inst., Tokyo). Nippon Genshiryoku Gakkaishi, 5: 481-91(June 1963). (In Japanese)

Results are presented on the oxidation rate of the dummy, uranium rod clad in punctured Magnox, by carbon dioxide, air, and their equi-volume mixture at 450 and 550°C. The effects on the oxidation rate of the presence of water vapor in the oxidizing atmospheres, of the pinhole diameter of the cladding, and of chemical additives in the uranium are also presented. Weight gains by carbon dioxide oxidation were 100 and 7 mg/day at 550 and 450°C respectively for a specimen with a pinhole of 1.0 or 0.5 mm dia, and 5 wt % of water vapor increased the weight gains remarkably. Heating the specimen in carbon dioxide at 550°C caused only a slight swelling within a day. Weight gain by air oxidation was approximately 1,000 mg at 550°C for a specimen with a pinhole of 1.0 mm dia, and the effect of the pinhole diameter was not negligible at the beginning of the oxidation. A log-log plot of weight gain as a function of oxidation time was a straight line with one break point which was not observed in the case of carbon dioxide oxidation. (auth)

**32528** KINETICS OF THE ANODIC OXIDATION OF ZIRCONIUM IN SOME ELECTROLYTES. A. Ya Shatalov and T. P. Bondareva (Voronezh State Univ., USSR). Zh. Fiz. Khim., 37: 1321-7(June 1963). (In Russian)

Equations for the ionic current strength in the anodic oxidation of Zr in 1 N $H_2SO_4$, $H_3PO_4$, and KOH solutions were derived for steady state rates of potential growth with time, assuming that the only anodic process is the formation of a $ZrO_2$ film. In the case of $H_2SO_4$ and $H_3PO_4$ calculation of the anodic current is carried out according to the equation

$$i = \text{const.} \exp\left\{2.303 \frac{R_i}{dR_i/d\lg i}\right\}$$

The corresponding expression for KOH solution is of the form: $i = \text{const.} \exp\{B_+F - F^2\}$. On prolonged anodic oxidation of Zr with constant density current a maximum potential value is obtained that remains constant unless breakthrough of the oxide film occurs, leading to abrupt fall in potential. It is suggested that under the influence of internal stresses, new formation of oxide film in the steady state occurs at the same rate as its breakdown so that the effective thickness of the film remains constant. (auth)

**32529** STRESS-CORROSION CRACKING OF SOME AUSTENITIC STAINLESS STEELS AS AFFECTED BY SURFACE TREATMENT AND WATER COMPOSITION. D. Birchen and G. C. Booth. 12p. (CONF-28-3)

From International Congress on Metallic Corrosion, New York, Mar. 1963.

A simple static autoclave test was developed for studying the stress-corrosion cracking of austenitic and stainless steels in high-temperature and high-pressure water of relatively high purity. Chloride contents varying from 0.2 ppm upwards in water initially saturated with air can cause cracking under these conditions. A threshold strain was observed below which rounded pits occur and no cracks develop. Above this strain cracking is preceded by the formation of angular pits. The threshold strain is reduced by prior plastic deformation, and the time for initiation of cracking is reduced by pickling. Emphasis is given to the need to avoid cold work on stainless steels that are to be exposed to a pressurized-water environment. (auth)

**32530** THE STRESS CORROSION OF ALUMINUM–ZINC MAGNESIUM ALLOYS WITH SPECIAL REFERENCE TO ELECTRODE POTENTIAL MEASUREMENTS. D. E. Piper (Boeing Co., Renton, Wash.). 41p. (CONF-28-2)

From International Congress on Metallic Corrosion, New York, Mar. 1963.

A polarization model was developed to account for the occurrence of a maximum susceptibility to failure by stress corrosion of a high-purity ternary Al–Mg–Zn alloy (2.5% Mg + 5.5% Zn) on aging at 120°C. Both the polarization model and controlled, selective etching experiments suggest that electrochemical relations between constituent phases in the alloy may account for the observed shape of the stress-corrosion life versus aging-time curve. Anodic polarization and controlled etching experiments were also carried out on several high-purity quaternary, quinary, and senary alloys and the results related to their susceptibility to failure by stress corrosion. (auth)

**32531** STRESS-CORROSION CRACKING STUDY OF SEVERAL HIGH-STRENGTH STEELS. R. A. Davis, G. A. Dreyer, and W. C. Gallaugher (Boeing Co., Renton, Wash.). 52p. (CONF-21-2)

From National Association of Corrosion Engineers Meeting, New York, Mar. 1963.

The stress-corrosion cracking susceptibility of four low alloy steels was evaluated by alternate immersion testing in a 3.5 percent salt solution. The variables investigated were heat treatment, strength level, test stress level, notch sensitivity, and mode of fracture. Results show that notch sensitivity can be correlated with stress corrosion cracking susceptibility. At strength levels below 200 ksi, all steels showed adequate resistance to stress-corrosion cracking. At strength levels above 200 ksi, the following alloys are most resistant to stress corrosion cracking at the indicated strength levels: 4340 M 600°F temper, 270 to 300 ksi; 4330 M 400°F temper, 240 to 260 ksi; H-11 1100°F temper, 220 to 240 ksi. Limited testing was carried out on two precipitation hardening stainless steels, AM350 and AM355. (auth)

**32532** THE USE OF $\beta$-SPECTROSCOPY FOR THE STUDY OF ANODIC OXIDATION. J. P. S. Pringle and J. A. Davies (Atomic Energy of Canada Ltd., Chalk River, Ont.). 5p. (CONF-68-5)

From Electrochemical Society, Pittsburgh, Apr. 1963.

Anodic oxidation of metal foils can be studied by injecting $Xe^{125}$ atoms into the foils, measuring the beta spectrum, anodizing the foils, and measuring the beta spectrum again. Calibration of the method was achieved by injecting $Xe^{125}$ into Al and W foils. The method was applied to the anodization of W, Nb, Ta, and Al, and the reasons for the discrepancies are discussed. (D.L.C.)

## Fabrication

*Refer also to abstracts 33247, 33248, 33276, 33277, and 33278.*

**32533** (AD-409795) EFFECTS OF WELD POOL AGITATION ON WELD PROPERTIES AND CHARACTERISTICS: AN ANNOTATED BIBLIOGRAPHY. Scott J. Buginas, comp. (Lockheed Missiles & Space Co., Sunnyvale, Calif.). May 1963. 21p. (SB-63-10)

The 40 references on effects of weld-pool agitation on weld properties cited were selected primarily from the literature of 1958 to 1962. Pertinent papers on the influence of vibrations during the solidification of castings are included. Abstracts are arranged in alphabetical order by author. A subject index is included. (auth)

**32534** (CONF-50-3) FABRICATION OF THIN URANIUM DIOXIDE PLATES BY A POWDER ROLLING PROCESS. Jarvis J. Fargo (International Pipe and Ceramics Corp., Los Angeles). [nd]. 14p.

From American Ceramic Society Meeting, Pittsburgh, Penna., Apr.–May 1963.

Thin, uniform plates of urania were produced by a powder-rolling process. Six types of urania powder were evaluated for their rolling characteristics, as were a number of organic binder additions to the urania powder. For urania powder, the rolling process appeared limited to producing rolled strip in the 0.020 to 0.100 in. thickness range. Rolled sheet could be punched to give flat plates with intricate patterns of perforations and contours. These plates, when sintered to 1700°C in hydrogen atmosphere, reached a bulk density of 10.40 g/cm$^3$. (auth)

**32535** (CONF-50-15) MATERIAL TRANSPORT DURING SINTERING OF FLUORITE STRUCTURE MATERIALS. C. S. Morgan and C. S. Yust (Oak Ridge National Lab., Tenn.). [1962]. Contract W-7405-eng-26. 26p.

From American Ceramic Society Annual Meeting, Pittsburgh, Pa., April–May 1963.

The sintering rate of thoria powder compacts and of compacts of other fluorite structure materials was investigated during the initial period of rapid densification. The densification rate, determined as a function of temperature with temperature increasing at controlled rates, increased to a maximum, decreased to a minimum, and then rose again. Except under extreme conditions, compacts brought to temperature had a temperature-dependent density despite variations in the heat-up cycle. When the sintering temperature of $ThO_2$ was raised, the increase in densification rate was much greater than the corresponding increase in the diffusion coefficient of thorium, the slower diffusing species, indicating that bulk diffusion is not the dominant material transport mechanism. The densification behavior was compatible with transport of material by dislocation movement. Prolonged holding at an intermediate temperature before heating to the final sintering temperature resulted in a curtailment of the densification, suggesting the operation of two or more transport mechanisms which are not contributing to sintering in the same manner. (auth)

**32536** (GEAP-4282) DESIGN AND FABRICATION OF COEXTRUDED STAINLESS STEEL CLAD $UO_2$ FUEL RODS. C. J. Baroch (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). June 1963. Contract AT (04-3)-189. 24p.

A process was developed in which stainless steel-clad $UO_2$ fuel rods are fabricated by high-temperature coextrusion. The process has a potential of being a more economical method for the preparation of stainless steel-clad $UO_2$ fuel rods than the conventional pellet process. Consequently, it was considered advantageous to evaluate the irradiation characteristics of fuel rods fabricated in this manner. Therefore, 24 coextruded fuel rods were manufactured for evaluation in a reactor. The required amounts of $UO_2$ and clad were soaked in separate containers at 1875 and 760°C, respectively. The containers were removed from their respective furnaces and were coextruded in one pass. A force of 450 to 475 tons was used, and a reduction ratio of 18 to 1 was obtained. The coextruded rods were cut to the approximate length, and the ends were sealed with an acid-resistant tape. The carbon steel can covering the stainless steel clad was removed by immersion in 1:1 nitric acid for 20 minutes. The rods were visually inspected, the specified lengths of clad and fuel were obtained by machining, and the correct diameter was obtained by belt sanding. The fabrication of the fuel rods was com-

pleted by inserting the plenum support tubes and welding in the end plugs. Nineteen of these fuel rods were sent to the Atomic Power Equipment Department (APED) for irradiation in the Vallecitos Boiling Water Reactor (VBWR). The irradiation of 12 of these rods was begun in August 1961, while the irradiation of 3 rods was begun in July 1962. The irradiations will continue until an average burnup of at least 10,000 Mwd/t is achieved by some of the fuel rods. (auth)

**32537** (HW-SA-2904) HANFORD PLUTONIUM FUEL DEVELOPMENT LABORATORY. L. G. Merker and I. D. Thomas (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Feb. 13, 1963. Contract AT(45-1)-1350. 14p. (CONF-39-28)

From American Nuclear Society Meeting, Salt Lake, City, Utah, June 1963.

The Plutonium Fabrication Pilot Plant (PFPP) is described. Glove-box-enclosed equipment is provided for plutonium fuel research, development of new fabrication processes, and fabrication of experimental reactor fuels containing plutonium. The design philosophy of the facility is containment and directional ventilation control. The glove boxes are constructed of stainless steel with acrylic plastic panels. Plastic glove ports are ordinarily cemented to the panels. (M.C.G.)

**32538** (NMI-2801) SUMMARY OF PROGRESS ON THE STUDY OF BETA TREATMENT OF URANIUM, NOVEMBER 1, 1959–AUGUST 31, 1960. R. B. Russell (Nuclear Metals, Inc., Concord, Mass.). Sept. 23, 1960. Contract AT(30-1)-1565. 68p.

Variables affecting the texture and grain size of uranium during beta treatment are summarized. The study of the effect of time and temperature in the beta phase on the growth index (G3) and grain size of the final alpha product is tentatively believed to show that higher beta temperatures for short times (up to about seven minutes) tend to promote slightly more negative growth indices and that higher beta temperatures give rise to somewhat finer grain sizes. Results of studies of both Jominy end-quenched bars and several full-sized rods and tubes quenched by total immersion showed that large thermal gradients promoted negative growth indices and produced grains somewhat elongated in the direction of the thermal gradient. The effects of end-cooling in full-sized pieces quenched by total immersion in cold water showed that the axial growth index is negative up to distances from the end of about half the wall thickness of tubes and about half the radial dimension of rods. The grain refinement penetrates to a lesser distance from the ends. In the radial direction the growth index for these same pieces is largely negative to a distance below the outer diameter of about midwall in two tubes studied. In the case of one tube which was studied more completely, the growth index became negative again as the inner diameter was approached. A water-quenched rod was found to have a negative growth index down to a distance from the surface of about midradius. (auth)

**32539** (NMI-2805) PROGRESS ON THE STUDY OF BETA TREATMENT OF URANIUM, AUGUST 1, 1961–NOVEMBER 30, 1961. R. B. Russell and A. K. Wolff (Nuclear Metals, Inc., Concord, Mass.). Dec. 29, 1961. Contracts AT(30-1)-1565 and AT(30-1)-2784. 100p.

Variables affecting the texture and grain size of uranium during beta treatment are summarized. The effects of composition (ingot versus dingot), prior delta condition, prior texture, pre-quenching air delay, rod or tube size, quenching medium and applied stress on grain size, distortion, and $G_3$ gradients in the final beta-treated shapes are described. (N.W.R.)

**32540** (TID-19161) SPECIFICATION [FOR] WELDING OF STAINLESS STEEL FOR STRUCTURAL QUALITY WELDS FOR MILDLY CORROSIVE NON-RADIOACTIVE SERVICE. P. S. Kingsley (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Apr. 5, 1963. Contract AT(45-1)-1350. 7p. (HWS-8242(Rev.5))

Requirements for fusion welding to obtain structural quality welds in stainless steel vessels, piping and piping systems, and other equipment for use in the chemical processing of nonradioactive, mildly corrosive materials are presented. The welding processes used are the manual inert-gas-shielded tungsten-arc process and the manual shielded metal-arc process, or a combination of both. (M.C.G.)

**32541** (FTD-TT-62-1677) WELDING IN USSR. Translated from p.127-254 of "Svarovani v SSR. Part II" (a publication of Slovenske Vydavatelstvo Technickej Literatury, Praha, 1961). 207p.

Topics covered in this study of welding in the USSR include: development of welding, weldability and manual arc welding, submerged-arc and electroslag welding, welding in protective gas medium, electrowelding equipment, resistance welding, gas-flame treatment of metals, new methods of welding, arc surfacing, soldering metals, strength of welding joints and parts, methods of inspecting quality of welds, and examples of welded structures in different branches of the national economy. (M.C.G.)

**32542** (UCRL-Trans-953(L)) MECHANISM OF THE INITIAL STAGES OF SINTERING OF SINGLE- AND TWO-COMPONENT CRYSTALLINE POWDERS. R. Pampuch. Translated by Sergey Shewchuck (Univ. of California Lawrence Radiation Lab., Livermore) from Prace Inst. Hutniczych, 14: 75-80(1962). 20p.

The model theories of sintering worked out by Kuczynski, Kingery and Berg, Coble, and others take no account of conditions which exist in real crystalline powders. Consequently the course of the initial stages of sintering in real systems did not agree with expectations inferred from the model considerations. The rearrangement of particles in sintering causes the number and area of interparticle contacts to increase and therefore allows an effective diffusional mass transfer during the subsequent stages. The time dependence of shrinkage during initial stages of sintering of narrow particle fractions of a number of oxides as well as an analysis of sintering of fractions with different average particle diameters by means of Herring's scaling laws indicated, that the initial sintering stages involve viscous slip of particles past each other as expected in the case of rearrangement. When these processes are completed, the kinetics of sintering conforms to volume diffusion mass transfer as postulated in the model theories. These observations and views allow a rational and homogeneous explanation of the previously established inverse proportionality of sinterability of pure oxides and fluorides and their specific free surface energy as well as the course of sintering in some two-component systems which form compounds in the solid state or limited solid solutions. (auth)

**32543** MANUFACTURE AND PROPERTIES OF SLIP CAST CRUCIBLES OF CALCIUM FLUORIDE AND THEIR USE IN THE SMELTING OF URANIUM. P. Rado (Worcester Royal Porcelain Co. Ltd., Worcester, Eng.). Ber. Deut. Keram. Ges., 40: 85-90(Feb. 1963). (In German)

Pressed (tamped) vessels of $CaF_2$ were used for the production of U, especially because $CaF_2$ is formed in the reduction of U and Ca. Such vessels are, however, porous and their efficiency is decreased. A substantial improvement was achieved by completely dense crucibles

manufactured according to the slip-casting process. The casting of $CaF_2$ is described, along with its properties, especially the high thermal expansion. The application of slip-cast $CaF_2$ crucibles in the smelting of U is described and such crucibles are compared with those of other materials. (TCO)

**32544** SINTERING OF $UO_2$. N. Mueller (NUKEM Nuklear-Chemie und Metallurgie GmbH, Wolfgang, Ger.). Ber. Deut. Keram. Ges., 40: 140-5(Feb. 1963). (In German)

The most important factors influencing the sintering in $UO_2$ are discussed. The results of some measurements are described that illustrate the influences of: the specific surface of the initial powders, the density after pressing, the O/U ratio during firing, impurities, firing temperature, and firing time. The influence of the pore structure on firing behavior is discussed in detail. Technological problems arising during the manufacture of sintered $UO_2$ articles are also discussed. A great variety of known methods are given. In the production of sintered articles the choice of the manufacturing method is largely governed by the specific surface of the initial powder. (auth)

**32545** PLASMA-ARC SPRAYING OF REFRACTORY METALS. D. R. Mash. Can. Machinery Metalworking, 73: No. 8, 81-3(Aug. 1962).

Applications for plasma-arc spraying include coating mild steel with Mo and fabricating tungsten rocket nozzles on graphite mandrels. Maximum plasma spray particle sizes are given for the refractory metals and for 304 stainless steel, TaC, BeO, and $ZrO_2$. (Rev. Metal Lit., 19: No. 11, Nov. 1962)

**32546** THE EXTRUSION OF BERYLLIUM. Paul Loewenstein. Current Eng. Practice, 4: 16-20(Feb. 1962).

The hydrostatic pressing, rolling, and extrusion of Be powder with subsequent canning of the billet with carbon steel are reported. An analysis was made of the extrusion forces and metal flow mechanisms. Data are given for preferred orientation and ductility as a function of the extrusion ratio. Comparative microstructures are given showing the relative grain size of extruded and cast Be. (Rev. Metal Lit., 19: No. 8, Aug. 1962)

**32547** BRAZING GRAPHITE TO ITSELF AND TO OTHER MATERIALS. R. G. Donnelly and G. M. Slaughter. Engrs'. Dig., 31: 81-2; 88(July 1962).

An investigation was made on the feasibility of brazing graphite-to-graphite and graphite-to-metal joints and the development of corrosion-resistant alloys that wet and flow on graphite. The results indicate a Ti-cored Ag–Cu alloy to be useful in low and intermediate temperature graphite brazing applications and the T-joint brazability of a Ti–Zr–Be developmental alloy. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**32548** SPECIAL DEVICE FOR THE HERMETICAL SEALING OF STANDARD ALUMINIUM IRRADIATION CAPSULES. H. Timm. Kerntechnik, 5: 253-4(June 1963). (In German)

A description is given of a special device for the hermetic sealing of standard aluminum irradiation capsules. During the welding process, the inside temperature does not exceed 50°C so that the capsules may contain heat-sensitive substances. (auth)

**32549** RESISTANCE SEAM WELDING APPLIED TO STAINLESS STEEL SHEATHS FOR NUCLEAR REACTOR FUEL ELEMENTS. C. Bridoux and G. Fischer. Soudage Tech. Connexes, 16: 383-98(Sept.-Oct. 1962). (In French)

Techniques, parameters, and equipment for resistance seam welding of 304 L, 316 L, and 347 stainless steel heat-treated or cold-deformed sheets with improved impermeability, rupture, and mechanical resistance are discussed. (Rev. Metal Lit., 20: No. 2, Feb. 1963)

**32550** SINTERING OF URANIUM OXIDE IN A CONTINUOUS FURNACE. R. Hauser and A. Porneuf (Compagnie Industrielle de Combustibles Atomiques Frittés, Orsay, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/17. 26p. (CONF-120-11). (In French)

Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

A continuous furnace, sintering under a reducing atmosphere at high temperature, was designed and constructed. The characteristic features of the furnace are automatic operation, rigorous control of presintering and sintering atmospheres, flexibility of temperature regulation so that the thermal cycle can be adjusted to the product to be sintered, and high output (5 tons of uranium oxide per month). It can operate continuously up to 1700°C, the presintering taking place at a lower temperature (800°C) in a preliminary furnace that forms an integral part of the whole. The sintering atmosphere is cracked $NH_3$ or pure H; the presintering atmosphere is a mixture of about 10% H and 90% N. The sintered pellets densify to above 97% of theoretical density, with a total dispersion of less than 1%. Structurally, they are equi-axed grains of about 10 μm. It was established that the stoichiometric variation of the uranium oxide sintered in a continuous furnace was less than 0.005. (auth)

**32551** INDUSTRIAL FABRICATION OF DENSE URANIUM CARBIDE BARS. A. Porneuf and R. Hauser (Compagnie Industrielle de Combustibles Atomiques Frittes, Orsay, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/18. 18p. (CONF-120-12). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The research, design, and industrial development involved in an original process for the fabrication of U carbide bars by arc melting and casting are described. By this process, molded U carbide ingots or bars with physical and chemical characteristics having very close tolerances are obtained. The characteristic feature of the single melting and casting apparatus is the method of casting, which is entirely self-determined and requires no special mechanical devices. Various parameters involved in the melting and casting are discussed. To illustrate industrial-scale production, the results obtained in the fabrication of 2 tons of U carbide bars are given. (P.C.H.)

**32552** THE INFLUENCE OF TIME UPON VIBRATORY COMPACTION OF THE $UO_2$ POWDER. B. Zivanović, D. Jovanović, and M. M. Ristić (Boris Kidric Inst. of Nuclear Sciences, Belgrad). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/55. 16p. (CONF-120-16). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The influence of frequency, acceleration, power, and binder, as well as vibration time, upon the vibratory compacting of different oxides ($UO_2$, $SiO_2$, MgO, $Al_2O_3$, CuO, and PbO) was investigated. The optimal values achieved for frequency, acceleration, and power, which were maintained on a constant level, enabled the examination of some other factors upon vibratory compaction, as for example: density of oxide powders and particle size distribution. The vibratory compaction time was found to have a con-

siderable influence upon the density of the vibratory compacted specimens; the maximum densities were obtained after 15 min, but the gradient of density was negligible after about 5 min. (P.C.H.)

**32553** MAGNESIUM CERMETS AND MAGNESIUM–BERYLLIUM ALLOYS. V. E. Ivanov, V. F. Zelenskii, S. I. Faifer, S. M. Zhdanov, V. I. Maksimenko, and V. I. Savchenko. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/67. 19p. (CONF-120-22). (In Russian)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Results of work on the development of Mg–MgO cermets and of super heat-resistant Mg–Be alloys produced by powder metallurgical methods are described. The introduction of even a minute quantity of finely dispersed MgO into Mg results in a strengthening of the material, the degree of which increases with increased MgO concentration. At 20°C, in the case of the cermets, $\sigma_B$ = 28 to 31 kg/mm$^2$ and $\delta$ = 3.5 to 4.5%; at 500°C $\sigma_B$ = 2.6 to 3.2 kg/mm$^2$ and $\delta$ = 30 to 40%. The positive effect of the finely dispersed oxide phase is particularly evident in protracted tests. Characteristic of the mixtures is high thermal stability of the strength properties. Powder metallurgical methods yielded super heat-resistant Mg–Be alloys containing increased concentrations of Be (PMB alloys). In air at 580°C, PMB alloys with 2 to 5% Be maintain a high resistance to oxidation for a period of over 12–14 thousand hours. The long-term heat resistance is due in the main to the amount of beryllium in the alloy, and increases with increasing beryllium content. PMB alloys are also marked by high resistance to short bursts of overheating. (P.C.H.)

**32554** IMPREGNATION OF GRAPHITE WITH SILICON IN A VACUUM. V. E. Ivanov, V. F. Zelenskii, M. G. Kolendovskii, and L. D. Kolomiets. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/68. 10p. (CONF-120-26). (In Russian)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

A study was made of the possibility of producing high thermal resistance graphite–SiC materials by means of impregnating MG graphite with liquid Si in vacuo. An attempt is made to explain the mechanism and origins of the degradation of products during the impregnation process. On the basis of the research a number of technical requirements, observance of which makes it possible to produce graphite–SiC materials by means of impregnation of graphite with liquid Si in vacuo at temperatures of 1450 to 1600°C, are suggested. (auth)

**32555** ON THE THEORY OF FABRICATION OF COMPACTED URANIUM DIOXIDE PELLETS BY POWDER METALLURGICAL METHODS. M. Podešti and L. Jakešová (Inst. of Nuclear Physics, Czechoslovak Academy of Sciences, Řež). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/61, 28p. (CONF-120-18). (In Russian)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Theoretical conclusions regarding processes for pressing and sintering $UO_2$ containing super-stoichiometric oxygen are described. The compactibility of a number of preparations of $UO_{2+x}$ in powder form and varying specific surface was investigated. A coefficient was derived characterizing the degree of agglomeration of the initial crystallites of the powder material. For mathematical interpretation of the compactibility over the range of pressures used, recourse was had to the Balshin equation. A relation was established between the coefficient of compactibility and the degree of agglomeration of the powder dioxide. The effect of super-stoichiometric oxygen of the $UO_{2+x}$ phase upon sintering in a reducing atmosphere of hydrogen occurs mainly during the initial stages of the process. The mechanism of the various phases of the sintering process and the factors governing the mechanism are discussed. It is shown that a relation exists between the degree of agglomeration of the powder preparation crystallites and the coefficient of pore volume reduction. Equations are derived for calculating volume reduction in the sintering of compacts having varying degrees of crystallite agglomeration. (auth)

**32556** A NEW PROCESS FOR PRODUCING LITTLE $UO_2$ SINTERED SPHERES BASED ON ISOSTATIC PRESSING. C. Bondesan, E. Brutto, A. Gioia, G. Perona, and R. Sesini (Centro Informazioni Studi Esperienze, Milan). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/5, 42p. (CONF-120-4). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

A process described for the fabrication of little $UO_2$ sintered spheres consists essentially in forming the little spheres in a die and then in pressing them isostatically. Studies were made on the most suitable alloying elements, lubricants, and solvents for good die-forming at very low pressure, the drying processes before pressing, and finally the best pressing conditions. The last operation was made very easy by eliminating the impermeable coating of the spheres to be pressed; this was possible using a very viscous fluid, which does not penetrate into the porosities of the sphere's body. A particular study was devoted to the effect of the value of the isostatic pressure on the density after sintering. The results obtained from density measurements and from metallographic observation (both with the optical and the electronic microscope) were compared to those obtained by pellets produced (starting from the same powder) with standard processes. (P.C.H.)

**32557** ELECTRON BEAM WELDING OF REFRACTORY MATERIALS FOR ION PROPULSION SYSTEMS. S. Robelotto (Hughes Research Labs., Malibu, Calif.). 30p. (CONF-57-4)

From Electron Beam Symposium, Boston, Mar. 1963.

Electron beam welding was used to solve the problem of joining a porous W emitter to a nonporous W support. A special holding device and jig were designed to hold the parts in position. Three-in. and ten-in. annular ionizers were fabricated successfully in this way. A method was developed for sealing the surface areas around and between the contoured sections in a multistrip porous W emitter, and the emitter was then welded into a manifold. Electron-beam welding was also used successfully to join W, Re, Mo, and Ta to Mo. (D.L.C.)

**32558** IMPROVEMENTS IN CERAMIC ARTICLES. (to Minnesota Mining and Mfg. Co.). British Patent 931,096. July 10, 1963. Priority date July 2, 1958, United States.

A rigid honeycomb structure of sintered material and methods of producing it are patented. The structure is formed from one or more corrugated sheets, in which nodes of the corrugations of one sheet are joined by sintered welds to other nodes of the same sheet, to nodes of another corrugated sheet, or to a noncorrugated sheet. All of the sheets are of sintered material with a thickness no greater than 0.125 in. or 0.05 in. The structure is produced by forming flexible sheets of sinterable particles, corrugating the sheets, forming a structure in which the

nodes of the corrugations are in contact with other nodes or with a noncorrugated sheet, and sintering the structure to a rigid state. The patented material can be used in ceramic heat exchangers, turbine blades, reactor fuel elements, and many other applications. (M.P.G.)

**32559** FUEL ELEMENT FOR A NEUTRONIC REACTOR. Robert K. McGeary and Fitz R. Winslow (to U. S. Atomic Energy Commission). U. S. Patent 3,100,742. Aug. 13, 1963.

A method of making fuel elements wherein several individual fuel pellets are positioned into a cladding tube and the tube stretched longitudinally until the cladding tube grips each pellet and, in addition, necks down between each pellet is described. (AEC)

## Properties and Structure

*Refer also to abstracts 33261 and 33263.*

**32560** (AAEC/TM-199) BINARY AND TERNARY SYSTEMS INVOLVING BERYLLIUM OXIDE. A LITERATURE SURVEY. D. Kairaitis (Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). June 1963. 27p.

Data relating to the binary and ternary systems involving beryllium oxide are presented. The survey deals with all available literature up to December 1962. (auth)

**32561** (AE-111) THE PARAMAGNETISM OF SMALL AMOUNTS OF Mn DISSOLVED IN Cu–Al AND Cu–Ge ALLOYS. H. P. Myers and R. Westin (Aktiebolaget Atomenergi, Stockholm). June 1963. 8p.

Previous measurements of the valency of Mn in Cu–Zn alloys were confirmed by measurements with the isoelectronic Cu–Al and Cu–Ge alloys as matrices for Mn. The valency, having the value 1 in pure copper, decreased slightly with increasing electron to atom ratio attaining the values 0.9 and 0.8 at the limiting composition in the Al and Ge alloys respectively. The apparent size of Mn in these alloys is discussed. (auth)

**32562** (AEET/CD/13) STUDIES OF THE ELECTRICAL PROPERTIES OF URANIUM OXIDES. I. ELECTRICAL CONDUCTIVITY OF $\alpha-U_3O_8$. A. M. George and M. D. Karkhanavala (India. Atomic Energy Establishment, Trombay). 1963. 21p.

The electrical conductivity of two grades of $\alpha$-$U_3O_8$ (nuclear pure and spec-pure) was studied as a function of temperature and partial pressure of oxygen in the ranges of 50 to 850°C and 150 to $10^{-2}$ mm of Hg. The log $\sigma$ vs. 1/T plots (for $P_{O_2}$ = 150 mm) show two linear portions with a break at about 450°C. The temperature dependence of conductivity is represented by the equation $\sigma = \sigma_0 e^{-\epsilon/2KT}$ with activation energies of 0.64 ± 0.03 and 1.10 ± 0.02 ev below and above the transition point respectively. In the high temperature region $\sigma_0$ could be regarded as constant with an average value of 138.4 $(\Omega\text{-cm})^{-1}$ for the nuclear pure material. The logarithm of conductivity varied linearly with log $P_{O_2}$ and the average slope of the plots was found to be −0.170 ± 0.006. The main features of conduction mechanism in the temperature range investigated are suggested. (auth)

**32563** (AERE-R-4347) THE EMISSION OF XENON-133 FROM LIGHTLY IRRADIATED URANIUM DIOXIDE SPHEROIDS AND POWDERS. D. Davies and G. Long (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). June 1963. 14p.

The post-irradiation heating technique was applied to determine the emission of $Xe^{133}$ from uranium dioxide in the form of both spheroids and powders. For sintered spheroids and powders the xenon emission data are consistent with those obtained previously for sintered compacts, (E = 70 kcal/mole, $D_{1400} = 5 \times 10^{-15}$ cm²/sec). No variations in diffusion coefficient due to differences in mode of preparation or in the degree of sub-division of the uranium dioxide were detected. Plasma-fused spheroids, on the other hand, after annealing to remove imperfections showed a high value for the activation energy (100 kcal/mole) and a lower value of diffusion coefficient at 1400°C ($4 \times 10^{-16}$ cm²/sec). (auth)

**32564** (ASD-TDR-63-635) THORIUM OXIDE–DIFFUSION OF OXYGEN, COMPATIBILITY WITH BORIDES, AND FEASIBILITY OF COATING BORIDES BY PYROHYDROLYSIS OF METAL HALIDES. H. S. Edwards, A. F. Rosenberg, and J. T. Bittel (General Electric Co. Advanced Technology Services, Cincinnati). July 1963. Contract AF33(657)-8470. 142p.

Measurements of self-diffusion of oxygen in $ThO_2$ were complicated by slow exchange at the surface. The measured values of the diffusion coefficient, D, ranged from $1.8 \times 10^{-13}$ cm²/sec at 800°C to $3.5 \times 10^{-8}$ cm²/sec at 1500°C. The rate constant of the surface reaction, K, ranged from $6.8 \times 10^{-10}$ cm/sec at 800°C to $1.3 \times 10^{-4}$ cm/sec at 1500°C. The results may be expressed by equations in the form of $D = 4.4 \exp(-65{,}800/RT)$ cm²/sec and $K = 7.6 \times 103 \exp(-63{,}800/RT)$ cm/sec. Attempts to deposit dense impervious layers of $ThO_2$ on selected solid borides by pyrohydrolysis of $ThCl_4$ were essentially unsuccessful. The main problem was attack of the borides by $CO_2$ in the coating gas. The pyrohydrolysis technique might prove to be an economical way to build up a coating of $ThO_2$ that was started by another method. The commercially available boride samples which were tested reacted with graphite in the temperature range of 2400 to 2700°C. Because of these reactions, a graphite-boride-thoria system will be useful for only limited times at temperatures above 2400°C. While pure borides were not investigated, it is expected that their behavior would be similar to that of the commercial samples examined in this work. (auth)

**32565** (ASD-TR-61-181(Pt.III)) SUBSTRUCTURE AND MECHANICAL PROPERTIES OF REFRACTORY METALS. B. S. Lement, D. A. Thomas, S. Weissmann, W. S. Owen, and P. B. Hirsch (ManLabs, Inc., Cambridge, Mass.). Apr. 5, 1963. Contract AF33(657)-8424. 220p.

Coordinated program on W, Mo, Ta, and Nb was carried out by means of advanced microscopic, x-ray-diffraction, and mechanical testing techniques. The effective surface energy for fracture of molybdenum strip was found to be about 3000 ergs/cm². The tensile ductility transition in molybdenum is associated with the occurrence of necking. Fibering in tungsten involves formation of ribbon-like grains containing a dislocation cell structure in which fine platelets occur. Discontinuous yielding in tantalum single crystals is correlated with a decrease in the shearing strain in the principal slip system to zero while that in the secondary system continues to increase. The binding energy between oxygen atoms and dislocations in tantalum is about 0.54 ev. Dissociation of screw dislocations along three interesting symmetrically located planes may account for the strong lattice friction stress in bcc metals. (auth)

**32566** (ATL-A-137) INVESTIGATION OF THERMAL-STRESS-FATIGUE BEHAVIOR OF STAINLESS STEELS.

Quarterly Progress Report No. 6, April–June 1963. K. E. Horton (Advanced Technology Labs. Div. of American-Standard, Mountain View, Calif.). Work performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-250. 48p. (EURAEC-756)

A study was made of the effects of specimen size and grain size on thermal-stress-fatigue (TSF) behavior of stainless steels. The competing nature of failure by specimen instability and failure by fatigue was disclosed and shown to be a complex problem. It was shown also that conventional fatigue results and TSF results conform for 304-L stainless steel for the variables studied. The testing of 304 and 304-L austenitic stainless steels, was essentially completed. The variables investigated in TSF include mean temperature of testing, time required for failure (hold time at temperature extremes), atmospheric surroundings, specimen size, material condition (annealed, cold-worked), and isothermal-fatigue comparative results. (auth)

**32567** (BMI-X-249) PROCESS DEVELOPMENT AND EVALUATION OF PROPERTIES OF F-48 NIOBIUM ALLOY. Final Report. Albert G. Imgram, Edwin S. Bartlett, and Horace R. Ogden (Battelle Memorial Inst., Columbus, Ohio). July 1963. For California. Univ., [Berkeley]. Lawrence Radiation Lab. Contract [W-7405-eng-92]. 124p.

The reproducibility of mechanical properties of the F-48 niobium alloy when the material is fabricated by warm extruding arc-melted ingots (both 2.8 : 1 and 5 : 1 extrusion ratios were used) and rolling to effect overall reductions on the order of 80 to 90% was evaluated. The rolled material was then heat treated for 1 hr at either 2525°F (reduced 80%) or 2400°F (reduced 90%), resulting in structures that were nominally 20% recrystallized. Generally, however, the material retained considerable structural attributes from the as-cast ingots. Ductile-to-brittle transition temperatures, either under slow-loading tensile testing or rapid impact conditions, were substantially above room temperature. Some tensile ductility was usually retained at room temperature. At temperatures above the transition-temperature region, tensile properties were consistent and reproducible. Material chemistry from heat-to-heat was consistent and reproducible. Creep strength at high temperatures (2200 and 2500°F) was erratic and far less reproducible without closer control of fabrication operations than was tensile strength. Creep strength sometimes varied from surface to central layers of rolled plate. With close process control, heavy plate of F-48 having both good room-temperature ductility and a 1% 10-hr creep strength at 2200°F of 15,000 psi could be produced. For the heats of F-48 evaluated, design to greater than 9000 psi for a 10-hr 1% creep life at 2200°F, or greater than 8500 psi for a total deformation of 1% in 10 hr at 2200°F would involve risk. (auth)

**32568** (CONF-53-5) ELEVATED-TEMPERATURE CREEP AND TENSILE PROPERTIES OF THREE COLUMBIUM-BASE ALLOYS. J. A. DeMastry, F. R. Shober, and R. F. Dickerson (Battelle Memorial Inst., Columbus, Ohio). [196?]. Contract W-7405-eng-92. 22p.

From World Metal Show, New York, Oct.-Nov. 1962.

In work to develop materials for elevated temperature applications, binary niobium alloys containing either 2.37 wt % chromium, 3.34 wt % zirconium, or 5.21 wt % vanadium were fabricated to sheet by forging at 550°C and rolling at room temperature. All three alloys were completely recrystallized after 90% cold work (reduction in thickness) and a one hour anneal at 1150°C. Tensile tests on the annealed materials at 650, 800, 1000, 1150, and 1315°C indicated that chromium, zirconium, and vanadium are potent strengtheners of niobium. At 1000°C the 2.37 wt % chromium and the 5.21 wt % vanadium alloys had 0.2% offset yield strengths of 38,000 and 38,300 psi respectively. At 1315°C, the 3.34 wt % zirconium alloy had a 0.2% offset yield strength of 14,700 psi. Stresses to produce creep rates of 0.0001, 0.01, and 0.1% per hour were determined for all three alloys at 650, 800, and 1000°C. The vanadium alloy exhibited the greatest creep resistance, requiring stresses of 52,700, 40,000, and 15,500 psi to produce a creep rate of 0.001% per hour at 650, 800, and 1000°C respectively. This research indicated that significant improvement in the mechanical properties of niobium can be achieved by alloying without undue sacrifice of fabricability. (auth)

**32569** (CONF-54-1) APPLICATION OF NMR TO TRANSITION METALS AND THEIR ALLOYS. D. O. Van Ostenburg, D. J. Lam, H. D. Trapp, and D. W. Pracht (Argonne National Lab., Ill.). Jan. 31, 1963. Contract [W-31-109-eng-38]. 5p.

From 4th Omnibus Conference on Experimental Aspects of Nuclear Magnetic Resonance Spectroscopy, Pittsburgh, February–March 1963.

The differences in nuclear magnetic resonance of metals and nonmetals are discussed. The interactions of conduction electrons with nuclei, eddy currents which are set up when the radiofrequency field is applied, preparation of materials for nuclear magnetic resonance studies, and internal magnetic fields in metals are considered. (M.C.G.)

**32570** (GA-2880) THERMAL STABILITY STUDIES OF GRAPHITE–MATRIX FUEL SYSTEMS. UNCOATED URANIUM–THORIUM CARBIDE FUEL AND PYROLYTIC-CARBON-COATED CARBIDE FUEL. W. V. Goeddel and H. K. Lonsdale (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Jan. 23, 1963. Contract AT (04-3)-314. 42p.

The thermal stability of graphite-matrix fuel systems containing both uncoated and pyrolytic-carbon-coated carbide fuel particles was evaluated in the temperature range of 1400 to 2000°C and for times of up to one year. No gross migration of uranium or thorium within the compacts was observed. Preferential vaporization of carbon from the surface of compacts was noted. Failure of some of the coated particles in thermal-gradient tests was found to be caused by the movement of the particle through the coating on the high-temperature side; this was named the "amoeba effect." Tests at temperatures of 1500°C and below showed that there should be no thermal instability of Peach Bottom coated particles for periods of at least three years (reference core life). The presence of atmospheric impurities did not significantly contribute to the vapor-phase transport of thorium or uranium. Also, the rate of loss of metals from the compacts is determined by the vaporization step and is not diffusion-limited. (auth)

**32571** (MSAR-63-105) EFFECT OF 1200°F SODIUM ON AUSTENITIC AND FERRITIC STEELS. PHYSICAL PROPERTIES OF MATERIALS. Progress Report No. 34, June 1963. (MSA Research Corp., Callery, Penna.). June 24, 1963. Contract AT(11-1)-765. 38p.

Tests 1 and 2, which consisted of the determination of the physical properties of Type 316 ss and 2¼ Cr-1 Mo steel specimens in low oxide sodium, helium, and air at 1200 and 1100°F respectively, were completed except for several tests in helium. Photomicrographs and discussion of stainless steel fatigue and creep-to-rupture specimens indicate that while massive oxidation products on stainless steel fatigue specimens are not apparent, as in the case of the

Cr–Mo specimens, surface attack is thought to reduce fatigue life. Evidence is shown that carburization is greater in short time stressed specimens than in 4000 hour exposed unstressed specimens. Test 3, the determination of the physical properties of stainless steel in 1200°F sodium saturated with carbon is in its shakedown stage. Test 4, the measurement of the physical properties of 2¼ Cr-1 Mo steel specimens in sodium containing 200 to 300 ppm sodium oxide, is in progress with several of the short time creep-to-rupture tests completed. Very preliminary evaluation of the test to date indicates a lower creep-to-rupture strength and a lower creep rate in this environment compared to sodium with low oxide. (auth)

**32572** (NP-13003) UBER UNTERSUCHUNGEN IN DEN SYSTEMEN URANOXID–EUROPIUMOXID UND PLUTONIUMOXID–EUROPIUMOXID. (On Investigations in the Systems Uranium Oxide–Europium Oxide and Plutonium Oxide–Europium Oxide (thesis)). Hermann Haug (Munich. Universitat). 1963. 97p.

The phase structures in the systems $UO_2$–$Eu_2O_3$ and $PuO_2$–$Eu_2O_3$ were investigated by x-ray spectroscopy with the help of the precision determination method for lattice constants. In the $UO_2$–$Eu_2O_3$ system a fluorite phase appeared after annealing at 1100°C at 38 to 64 mole % $EuO_{1.5}$, with lattice constants of 5.406 and 5.391 Å. On the uranium-rich side of the system, a second phase form existed with $UO_{2.6}$ with a mixed crystal with 38 mole % $EuO_{1.5}$. In the region of the fluorite phase, anion gaps were avoided by oxidation of the uranium to $U^{5+}$ and $U^{6+}$. The $PuO_2$–$Eu_2O_3$ system, after annealing at 1100°C, showed a continuous mixed series with a fluorite phase from pure $PuO_2$ to 42 mole % $EuO_{1.5}$. Both systems showed high thermal stability. (M.C.G.)

**32573** (ORNL-TM-607) MECHANICAL PROPERTIES OF INOR-8 CAST METAL. R. W. Swindeman (Oak Ridge National Lab., Tenn.). Aug. 6, 1963. Contract W-7405-eng-26. 9p.

Tensile and stress-rupture data for INOR-8 castings are presented. It is shown that the high-temperature strength of castings is sufficient to allow present Molten-Salt Reactor Experiment stresses for wrought metal to be used. At lower temperatures, however, the tensile strength limits the maximum stress to low values. The effect of defects in castings is illustrated. (auth)

**32574** (PWA-2184) BERYLLIUM DIFFUSION BARRIER COATINGS. Summary Report. J. J. Koziol (Pratt and Whitney Aircraft Div., United Aircraft Corp., Hartford, Conn.). [1962]. 42p.

Beryllium strips were plasma-arc-sprayed with chromium, iron, titanium, and beryllium oxide. Additional strips were electroplated with gold. The coated strips were exposed to temperatures of 1400°F and pressures in the range of $10^{-5}$ to $10^{-7}$ mm Hg for periods of 150 and 500 hours. After exposure, all of the coated strips except those coated with beryllium oxide were analyzed by x-ray diffraction to determine the extent of diffusion. Of the coatings exposed, only the beryllium oxide coatings remained intact for the duration of the exposure. The chromium and iron coatings separated completely, while the titanium coating spalled in localized areas. Interdiffusion between the gold coating and the beryllium substrate resulted in a brittle, highly blistered, nonadherent, unidentified phase. (auth)

**32575** (TID-19181) A STUDY OF DISLOCATION MOBILITY AND DENSITY IN METALLIC CRYSTALS. Progress Report No. 1, Period Ending July 31, 1963. [R. S. Wood and T. Vreeland, Jr.] (California Inst. of Tech., Pasadena. W. M. Keck Lab. of Engineering Materials). Contract AT(04-3)-473. 8p.

Single crystals of 99.99% pure aluminum were grown from seeds in a ½-in. diameter cylindrical graphite mold. Several single crystal test specimens of 99.999% pure and zone-refined zinc were prepared from 1-in. diameter crystals by spark cutting and planing. Tests indicated that the depth of surface damage resulting from spark planing is less than 0.007 in. Studies were conducted on the polishing and etching characteristics of oriented aluminum single crystals to find a technique that will produce etch figures where dislocations intersect (111) surfaces. Several loading systems were developed and constructed for direct and indirect studies of dislocation mobility. A fixture designed for compression tests on ½-in. cube zinc specimens or ½-in. diameter c-axis zinc cylinders was constructed. A dynamic torsion testing machine is under development for measurement of dislocation velocities up to approximately $10^4$ in./sec. Strain-rate tests were conducted on compression specimens of zinc. (M.C.G.)

**32576** (UCRL-10778) THE SUBSTRUCTURE OF PLASTICALLY DEFORMED NICKEL (thesis). Richard L. Nolder (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 1963. Contract W-7405-eng-48. 58p.

Transmission electron microscopy techniques were used to study the substructure of pure nickel deformed under static and shock loading conditions. The shock loading was carried out under originally ambient temperature conditions. Loads ranging from 70 to 700 kilobars. Static loading involved compressive loading at the ambient temperature and tensile loading at temperatures ranging from 4°K to the ambient temperature. A dislocation cell structure was found in all statically loaded specimens, as was observed previously, and in specimens shock loaded up to 250 kilobars. Microtwinning was observed for the first time in nickel shock loaded at 350 kilobars and higher. It was found that under initially ambient temperature conditions the energy input per unit volume was inversely proportional to the square of the cell diameter. A possible explanation for this was proposed, making use of Kuhlmann-Wilsdorf's theory for work hardening in which the energy required to bow out dislocation segments was equated to the inverse square of an average dislocation segment's length. A similar analysis was used to explain twinning. By making use of both analyses a quantitative relation between the average cell diameter and the average segment length was predicted which seemed consistent with observations. A prediction of the ratio between the rigidity modulus and the work hardening coefficient in Stage II of work hardening was consistent with actual measurement obtained from published data. It is proposed that this type of analysis should be applied to other metal systems. (auth)

**32577** (AEC-tr-5931) A STUDY OF THE URANIUM–ZIRCONIUM DIFFUSION IN THE GAMMA PHASE. Yves Adda and Jean Philibert. Translated by J. W. Colby (National Lead Co. of Ohio, Cincinnati) from Compt. Rend., 242: 3081-3(1956). 4p.

The U–Zr diffusion in the gamma phase was studied between 950 and 1075°C. The diffusion curves were obtained by employing the electron microprobe analyzer of Castaing. Results showed that the diffusion coefficients, the activation energy, and the frequency factor vary with concentration. (auth)

**32578** (AEC-tr-5932) STUDY OF THE KIRKENDALL EFFECT AND THE DETERMINATION OF THE CHEMICAL

AND INTRINSIC DIFFUSION COEFFICIENTS IN THE COUPLE U–Mo. Yves Adda and Jean Philibert. Translated by J. W. Colby (National Lead Co. of Ohio, Cincinnati) from Compt. Rend., 246: 113-16(1952). 4p.

In the course of obtaining evidence on the Kirkendall effect in the body-centered-cubic phase of the U–Mo couple, the intrinsic diffusion coefficients of uranium and molybdenum were calculated. The chemical diffusion coefficients from 800 to 1050°C and their variation with concentration were determined. A quantitative study was made of the Kirkendall phenomenon. (auth)

**32579** STRUCTURE AND MAGNETIC PROPERTIES OF ELECTROLYTIC LAYERS OF COBALT USED FOR NEUTRON POLARIZATION. A. Calusaru, S. Ripeanu, and L. Benes (Inst. of Atomic Physics, Bucharest). Acad. Rep. Populare Romine, Studii Cercetari Fiz., 14: 239-47(1963). (In Rumanian)

In order to obtain Co mirrors for the polarization of thermal neutrons, the optimum conditions and electrolytes to obtain deposits of Co with cubic crystalline lattice were determined. The best results were given by the electrolyte having the composition $CoSO_4 \cdot 7H_2O$ (140 g/l), boric acid (30 g/l) and a current density of 0.015 amp/cm$^2$ at 24°C and pH 2. The pH of the electrolyte exercises a strong influence on the magnetic properties of the Co deposits. Samples having 70% cubic lattice attain magnetic saturation in a magnetization field lower by an order of magnitude than Co with hexagonal lattice. (tr-auth)

**32580** NEUTRON AND X-RAY DIFFRACTION STUDIES OF NONSTOICHIOMETRIC METAL HYDRIDES. S. S. Sidhu, N. S. Satya Murthy, F. P. Campos, and D. D. Zauberis (Argonne National Lab., Ill.). Advan. Chem. Ser., No. 39, 87-98(1963).

The zirconium–deuterium system in addition to $\alpha$-Zr consists of three deuteride phases: $\gamma$, $\delta$, and $\epsilon$. Each phase exists over a wide range of compositions. The $\gamma$ phase is tetragonal. The $\delta$ phase is cubic ($CaF_2$-type). The $\epsilon$ phase is tetragonal. Its lattice constants vary with composition as it approaches stoichiometry of $ZrD_2$. The unit cell contains $4ZrD_2$ with atoms in similar positions as in the $\delta$ phase. The $\gamma$ phase retains its structure over long periods of time at room temperature. The $\delta + \epsilon$ region has a finite width. The sizes of interstitial octahedral and tetrahedral voids in $\alpha$-Zr are calculated and shown to be larger or smaller, respectively, than those of tetrahedral sites actually occupied by deuterium atoms in the deuterides to permit interstitial solid solution. (auth)

**32581** WESTINGHOUSE ALLOY B 33 (HIGH TEMPERATURE COLUMBIUM ALLOY). Alloy Digest Cb-1, 1-2(Aug. 1961).

The physical and mechanical properties, workability, machinability, and weldability information and applications are given for a high-temperature corrosion-resistant Nb alloy containing 5.0% vanadium. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**32582** NON-UNIFORM SHRINKAGE IN SINTERING. K. D. Reeve (Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales, Australia). Am. Ceram. Soc. Bull., 42: 452(Aug. 1963).

Three examples of nonuniform shrinkage are discussed to illustrate the variety of origins for the phenomenon and to show how the problem was overcome in each case. The examples were observed during sintering studies on BeO, $UO_2$–$ThO_2$, and BeO–$ThO_2$–$UO_2$ where the effect was detrimental to the attainment of highest densities. (P.C.H.)

**32583** PRESSURE SINTERING OF HAFNIUM, ZIRCONIUM AND TANTALUM CARBIDES WITHOUT BINDER. B. Lersmacher and S. Scholz. Arch. Eisenhuttenw., 32: 421-9(1961).

The equation for density as a function of sintering time, composition, particle size, and specific surface of powders was studied. Density versus time curves were also studied. The influence of additions of auxiliary metals, maximum 1% Mn, Co, or Ni and of 1 hr heating in vacu at 700°C, in part at 1400°C, upon densification and on the required activation energies was determined. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**32584** GRAINS AND GRAIN BOUNDARIES IN METALS AND CERAMICS FOR NUCLEAR ENGINEERING. G. V. Cullen (Univ. of Melbourne). At. Energy Australia, 6: No. 3, 2-8(July 1963).

Research work on grain boundary cavitation cracking in Mg and its alloys, deformation of ceramics, and thermal properties of ceramic oxides is outlined. (P.C.H.)

**32585** AN INVESTIGATION OF SOME PHYSICAL PROPERTIES OF SINTERED $UO_2$ BODIES AS A FUNCTION OF BeO ADDITIONS. D. Harkort, G. Honcia, and H. G. Kling (Battelle-Institut e.V., Frankfurt am Main). Ber. Deut. Keram. Ges., 40: 123-8(Feb. 1963). (In German).

The thermal conductivity and thermal expansion of sintered $UO_2$–BeO bodies was studied by determining the specific surface of the sample powders (by the BET method) and the ratio of O/U (by the oxidation method) and investigating their sintering behavior. The $UO_2$ specimens with 0, 5, 10, 15, and 20 vol % BeO added were prepared by cold pressing and subsequent sintering in a H atmosphere at 1550 and 1600°C. Their density was 95.0 ± 0.4% of the theoretical. The thermal conductivity was found in a cylindrical apparatus by determining, up to 1000°C, the heat supplied and the radial heat flow. The mean relative error $\Delta\lambda/\lambda$ was ±8%. The thermal conductivity of mixed bodies increased with increasing BeO content. Mixed bodies with a BeO content of 20 vol % had a thermal conductivity twice as high as that of pure $UO_2$. The thermal expansion of the specimens was determined up to 1100°C in a vertical apparatus with an accuracy of $\pm 0.2 \times 10^{-6}$ (cm/cm/°C). No relation between thermal expansion and BeO content could be found. Finally, the structure of some specimens was studied by x ray. (auth)

**32586** THE GROWTH OF $UO_2$ GRAINS. H. Stehle (Siemens-Schuckertwerke AG, Erlangen, Ger.). Ber. Deut. Keram. Ges., 40: 129-35(Feb. 1963). (In German)

The growth of sintered $UO_2$ grains between 1550 and 2100°C was studied. Each firing test was carried out on two specimens: one with a density of 10.3 g/cm$^3$ and the other with 10.5 g/cm$^3$. Although the activation energy was the same in both cases, the grains grew more slowly in the specimens with lower density, i.e., higher porosity. The dependence of the process on time can best be interpolated from an assumption $\bar{D}\,\sigma\,1/\bar{D}^2$ ($\bar{D}$ = mean grain diameter). The scattering of the individual values is very high, which can be explained by the nonhomogeneity of the specimens. Repetition of firing several times did not influence the results. With the progressing grain growth the number of pores decreases while their mean size increases, but only at a rate too low to halt the decrease of the pore volume as a whole. The statistical distribution of the grain size is in agreement with a logarithmic Gaussian curve, whose scatter remains about the same with increasing mean value. (auth)

**32587** URANIUM COMPOUNDS AS THERMOELECTRIC MATERIALS. I. H. Warren (Univ. of British Columbia, Vancouver). Can. Mining Met. Bull., 56: 288-98(Apr. 1963).

The properties required for a compound to form useful thermoelectric materials are described. Uranium compounds that might have the properties are reviewed. Several of the compounds were prepared and fabricated into compacts. The apparatus used for hot pressing, and for the measurement of thermoelectric power, electric conductivity, and thermal conductivity, is described. Detailed attention was given to the properties of the nitrides. Preliminary studies on a number of other U compounds are reported. The figures of merit of the best materials so far examined are one-tenth of those necessary for a useful thermoelectric material. (auth)

**32588** THE EFFECT OF THE PARTICLE SIZE OF SINTERED BERYLLIUM POWDER ON ITS APPARENT DENSITY AND ELECTRICAL RESISTIVITY. Hiroshi Nakatani. Denki Shikensho Iho, 26: 278-84(1962). (In Japanese)

The temperature coefficient of sintered, rolled, and annealed Be plate was determined. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**32589** THE FINE STRUCTURE OF SCANDIUM'S X-RAY ABSORPTION K-SPECTRA IN THE METAL AND IN SOLID REFRACTORY COMPOUNDS. E. A. Zhurakovskii and V. P. Dzeganovskii (Inst. of Metal-Ceramics and Special Alloys, Academy of Sciences, Ukrainian SSR). Dokl. Akad. Nauk SSSR, 150: 1260-2(June 21, 1963). (In Russian)

The K-absorption spectra of Sc in the pure metal, the diboride, monocarbide, and mononitride were investigated and the results are compared with those yielded by $Sc_2O_3$. The x-ray phase studies confirmed previous findings that the carbide and nitride of Sc possess an NaCl-type face-centered cubic lattice, with parameters of 4.5 and 4.44 Å, respectively, while the diboride has an $AlB_2$-type hexagonal structure, with a = 3.14, c = 3.52 Å; c/a = 1.056. The work was carried out with a focusing-type x-ray apparatus with a linear dispersion of 3.5 X/mm. The fine structure and the K-absorption edge of Sc were found to be the typical ones for transition metals. The absorption coefficients of Sc in the diboride, carbide, and nitride were found to be intermediate between those of the metal and the oxide. The data also seem to point to a different type of interatomic interaction than in the case of V and Ti, in spite of the lattice isomorphism. (TTT)

**32590** ZONE-MELTING OF OXIDES IN A CARBON-ARC IMAGE FURNACE. P. Kooy and H. J. M. Couwenberg. Engrs'. Dig., 23: 87-9(May 1962).

The formation of single and mixed crystals by zone-melting of Ni, Ti carbides, Zr, Ti, and oxides of Ti, Zr, and Ni, glass, $Al_2O_3$, and $MnFe_2O_4$ at 2320 to 3800°K in air with accompanying decomposition, solidification, and cracking is discussed. (Rev. Metal Lit., 19: No. 8, Aug. 1963)

**32591** THE ZIRCONIUM EFFECT IN ALUMINUM ALLOYS. Josef Czikel, Klaus Herfurth, and Roland Mai. Freiberger Forschungsh., 70B: 91-143(1962). (In German)

Test castings of Al–Zr alloys containing 0 to 2% Zr in metal dies and sand molds were made, along with a metallographic investigation of the effect of Zr on the formation of the macrostructure of the solidification zones. (Rev. Metal Lit., 19: No. 11, Nov. 1962)

**32592** ON CALCULATION OF A BOILING POINT. B. N. Oshcherin (Leningrad Inst. of Tech.). Inzh. Fiz. Zh., Akad. Nauk Belorussk. SSR, 6: No. 5, 23-8(May 1963). (In Russian)

The interdependence between the boiling point, characteristic temperature, and principal quantum number was established for compounds with uniform bounds. An expression was obtained for calculation of the boiling points of alkali metals accounting for the correction known in the combination principle of the spectroscopy for Li. Formulas are presented for analytical calculation of boiling points as well as for calculation of temperatures from thermal and elastic properties measured under conventional conditions. The relations derived may be used for preliminary estimation of boiling points of refractory metals and metal-like compounds. (auth)

**32593** SELF-DIFFUSION OF MOLYBDENUM IN Mo–Zr ALLOYS. M. B. Bronfin, S. Z. Bokshtein, and S. T. Kishkin. Issled. Splavov Tsvetn. Metal. Akad. Nauk SSSR, Inst. Met., No. 3, 12-18(1962). (In Russian)

Vacuum-arc melted specimens of Mo–Zr, containing 0.005 to 0.5% Zr and given amounts of Ti, Cr, W, C, and O were homogenized from 1950 to 2000°C and deformed 25% by forging at 20°C with subsequent diffusion annealing at 1700 to 2000°C. Mo self diffusion and activation energy coefficients were determined using $Mo^{99}$ tracers. The effects of diffusion temperature, Zr concentration, and degree of cold reduction on the diffusion coefficient were also investigated. (Rev. Metal Lit., 20: No. 1, Jan. 1963)

**32594** STUDY OF DECOMPOSITION OF SUPERSATURATED SOLID NEODYMIUM SOLUTION IN MAGNESIUM. M. E. Drits, Z. A. Sviderskaya, and L. L. Rokhlin. Issled. Splavov Tsvetn. Metal. Akad. Nauk SSSR, Inst. Met., No. 3, 68-73(1962). (In Russian)

Cast Mg alloy with 1.1 to 2% Nd was press-formed into rods (deformation 88%) and water quench hardened at 535°C. The rods were aged at 150 to 300°C from 2 to 100 hr. A comparison was made of the changing hardness, electroresistivity, and microstructure caused by each temperature of aging and by liberation of the Nd-rich phase from supersaturated solid solution. The optimal aging temperatures for achieving maximum hardness was determined as a function of Nd content. (Rev. Metal Lit., 20: No. 1, Jan. 1963)

**32595** INFLUENCE OF ADDITIONAL ALLOYING AGENTS ON PROPERTIES OF Mg–Th–Mn SYSTEM. M. E. Drits, M. V. Maltsev, Z. A. Sviderskaya, E. M. Padexhnova, and V. F. Trokhova. Issled. Splavov Tsvetn. Metal. Akad. Nauk SSSR, Inst. Met., No. 3, 86-92(1962). (In Russian)

The Mg–Th–Mn alloy with 2 to 3% Th and 0.6 to 1% Mn was alloyed by additions of Zr, Ca, La, Ni, Ce, and Nd, reduced by hydraulic press by 90% at 420°C, quenched from 550°C, and artificially aged at 200°C for 16 hr. The effects of the alloying elements and work hardening occurring during heat treatment on yield strength, tensile strength, relative elongation, and microstructure were measured at 300°C. The influence of Ce concentration on phase formation was also studied. (Rev. Metal Lit., 20: No. 1, Jan. 1963)

**32596** STRUCTURE AND PROPERTIES OF Mg–Th ALLOYS OBTAINED BY CRUCIBLE MELTING PROCESS. M. V. Chukhrov and Yu. D. Lukovnikov. Issled. Splavov Tsvetn. Metal. Akad. Nauk SSSR, Inst. Met., No. 3, 163-8 (1962). (In Russian)

Studies were made on the alloying of Mg–Th alloy by Mn and Zr, refining by addition of flux from 730 to 750°C and pouring the melt into a red hot crucible and melting by crucible process for 0.5 to 1 hr at 700 to 730°C followed by immersion of the crucible in cold water. The distribution of alloying elements on the height of the casting was determined by microscopy. The effect of the crucible process

duration (holding time) on liquation of Th, Zr, and Mg, and of liquation on yield strength, elongation, and grain size of Mg–Th, Mg–Th–Mn, and Mg–Th–Zr alloys was also studied. (TCO)

**32597** EFFECT OF RARE-EARTH METALS ON THE SOLUBILITY OF HYDROGEN IN LIQUID IRON. A. M. Yakushev, V. I. Yavoiskii, and Yu. V. Kryakovskii. Izv. Vysshikh Uchebn. Zavedenii, Chernaya Met., 44-54(July 1961).

Alloys of Fe were prepared with one of the four metals, Ce, La, Nd, or Pr. A variation of pressure in the system was found in the case of additions of 80% alloys of La, Nd, and Ce in H versus He atmospheres, at steel-making temperatures. (Rev. Metal Lit., 19: No. 8, Aug. 1962)

**32598** THE INFLUENCE OF RARE EARTH METALS ON SURFACE TENSION OF FUSED IRON. A. F. Vishkarev, Yu. V. Kryakovskii, S. A. Bliznyukov, and U. I. Yavoiskii. Izv. Vysshikh Uchebn. Zavedenii, Chernaya Met., 5: No. 3, 60-6(1962). (In Russian)

La and Ce were added to purified Armco steels of different composition and the change of surface tension was measured in the presence of interfering S and O impurities. The crystal structure of the alloys was compared with the structure of the original steel. (Rev. Metal Lit., 20: No. 1, Jan. 1963)

**32599** PHASE TRANSITIONS IN $LiAl_5O_8$. R. K. Datta and Rustum Roy (Pennsylvania State Univ., University Park). J. Am. Ceram. Soc., 46: 388-90(Aug. 21, 1963).

$LiAl_5O_8$ exists in many forms. The equilibrium high-temperature form (I) has a spinel structure. It undergoes a first-order reconstructive transformation at 1295° ± 5°C to an equilibrium low-temperature form (II) with primitive cubic symmetry, the unit edge changing from $a_0$ = 7.921 A (I) to $a_0$ = 7.907 A (II). In addition, a whole series of phases (II-metastable) exist with the same symmetry as II but with a disorder different from I → II disorder. (auth)

**32600** INFLUENCE OF STOICHIOMETRY ON THE RATE OF GRAIN GROWTH OF $UO_2$. I. Amato, R. L. Colombo, and A. M. Protti (FIAT, Turin). J. Am. Ceram. Soc., 46: 407(Aug. 21, 1963).

The grain diameter D of a polycrystalline metallic or nonmetallic specimen is given by $D^2 - D_0^2 = K_0 t^n \exp(-Q/RT)$, where $D_0$ is the grain diameter at time t = 0, T is the absolute temperature, R is the gas constant, Q is the activation energy, and n is a coefficient which is ideally unity. Normally, however, n takes somewhat different values because of the interference of pores, impurities, and concurrent sintering. The grain growth of stoichiometric $UO_2$ was measured several times and the results are summarized. Uranium dioxide is oxidized in both steam and $CO_2$ to an oxygen-rich nonstoichiometric form. The rate of grain growth in such material has not been reported previously. The measurements made during this study are reported. Pellets having an unfired density of ~6 g per $cm^3$ were pressed from ceramic-grade depleted $UO_2$ powder with minor additions of organic binder and lubricants. They were sintered isothermally at the temperatures shown, after which the grain size was measured. The value of t in the above equation was measured one-half hour after the furnace had reached the desired soaking temperature. Since grain growth was slower in the stoichiometric form, the specimens were heated and cooled in hydrogen. Each experimental point was calculated from twelve determinations by means of a digital computer on the basis of a first-order two-variable regression formula. Although the values of n and Q for steam and $CO_2$ are not significantly different, Q in both cases is much lower than that measured for stoichiometric $UO_2$. It is evident that oxygen-rich $UO_2$, which sinters faster than the stoichiometric material, also has a higher rate of grain growth. (auth)

**32601** THE DIFFUSION OF OXYGEN IN HAFNIUM. G. R. Wallwork (Univ. of New South Wales, Kensington, Australia) and W. W. Smeltzer. J. Electrochem. Soc., 110: 943-4(Aug. 1963).

Determinations of the oxygen diffusion constants in Hf at 800 and 950°C are reported. Hafnium specimens 0.025-in. thick were exposed in oxygen at 1 atm pressure at 800 and 950°C for 96 and 24 hr, respectively. The results ($3.8 \times 10^{-11}$ and $7.6 \times 10^{-10}$ at 800 and 950°C, respectively) suggest that the discrepancy between determinations from oxidation and diffusion anneal experiments at lower temperatures is associated with the Arrhenius-type extrapolation over a broad temperature range or the impure polycrystalline Hf specimens. (P.C.H.)

**32602** ANISOTROPY OF SURFACE PROPERTIES OF ALPHA–URANIUM. I. ANISOTROPY OF CATHODIC ETCHING. Yu. N. Sokurski, F. P. Butra, O. L. Fufaeva, and K. A. Ustavshikova (Academy of Sciences, Moscow). J. Nucl. Mater., 9: 59-64(June 1963). (In English)

Cathodic etching of U was studied in an Ar atmosphere. The anisotropy of etching was judged by the relief produced on the surface of polycrystalline $\alpha$-uranium specimens. The surface of crystallites close to the crystallographic planes {100}, {110} was shown to have the minimum rate of etching, while those close to {021} have the maximum rate. The relative difference between the extreme values of the etching rate amounts to 40%. The experimental results were qualitatively accounted for on the basis of the concept of focusing collisions, a preferred propagation of momentum into the lattice along close-packed directions and the small probability of the reversal of momentum in this case. Additional experiments on the cathodic etching of Cu yielded results that were in good agreement with the above explanation. (auth)

**32603** THE PRECIPITATION OF HELIUM DURING ANNEALING OF COLD-WORKED AND IRRADIATED Al–Li ALLOY. G. T. Murray and H. Kuzuu. J. Nucl. Mater., 9: 107-8(June 1963). (In English)

The recrystallization of irradiated and cold-worked Al–Li alloy containing He atoms was studied. During subsequent heating at 350°C of specimens that had been irradiated in the annealed state, it was found that after about 265 hr bubbles began to appear (by optical microscopy after etching in a hot 90% $H_3PO_4$–10% $H_2SO_4$ solution) at the grain boundaries. In cold-worked specimens, however, bubbles appeared much earlier in the heating process and after 68 hr could be seen readily in the form of a well-defined network. The network was found to consist of a very fine recrystallized grain structure. It is suggested that the bubbles formed and grew simultaneously with the recrystallization nuclei. The newly formed grains were then halted in their growth process when the bubbles reached a size sufficient to halt grain boundary migration. (P.C.H.)

**32604** SOME SEGREGATION EFFECTS IN SINTERED $UO_2$–$PuO_2$ PELLETS. B. Cina (Nuclear Materials and Equipment Corp., Apollo, Penna.). J. Nucl. Mater., 9: 111-13(June 1963). (In English)

An unusual segregation effect was observed in mechanically blended and sintered $UO_2$–$PuO_2$ pellets, the effect taking the form of multilayered spheres, alternately uranium- and plutonium-rich. The segregation was detected by an autoradiographic technique. Mechanical methods for

eliminating the effect were investigated, with promising results. A high degree of homogeneity was observed in sintered mixed oxides formed by a coprecipitation and coreduction technique. (P.C.H.)

**32605** ON THE GAMMA TO GAMMA PRIME TRANSFORMATION IN URANIUM–33 AT. % MOLYBDENUM. C. G. Rhodes and D. Kramer (Atomics International, Canoga Park, Calif.). J. Nucl. Mater., 9: 114-15(June 1963). (In English)

Comments are made on a previous work (Ivanov and Virgiliev, J. Nucl. Mat., 6: 199(1962)) on the $\gamma$ transformation mechanism in Mo–U based on x-ray diffraction measurements. It is also proposed that the transformation occurs by the formation of $\gamma'$ nuclei with some small degree of order. These grow as plates and continue to order simultaneously. (P.C.H.)

**32606** INFRARED SPECTRA AND ASSIGNMENTS FOR POLYVINYL CHLORIDE AND DEUTERATED ANALOGS. S. Krimm (Univ. of Michigan, Ann Arbor), V. L. Folt, J. J. Shipman, and A. R. Berens. J. Polymer Sci., Pt. A, 1: 2621-50(Aug. 1963).

Deuterated analogs of polyvinyl chloride (PVC) were prepared and their infrared spectra analyzed as an aid to the more detailed assignment of bands in the spectrum of PVC. The deuterated polymers studied were: PVC-$\alpha d_1$, PVC-$\beta d_1$, PVC-$\alpha\beta d_2$, and PVC-$d_3$. These, as well as PVC, were polymerized in urea-complex, at –78 and +50°C in order to determine which bands are of crystalline origin and which of noncrystalline origin. Polarized spectra of oriented samples were obtained in each case to assist in the analysis. As a result of the study several previously uncertain assignments were clarified. With the help of other studies on model chlorine-containing compounds it was possible to identify the various conformations present in the polymer and to associate these with isotactic and syndiotactic pair configurations in the chain. A method is suggested for determining the proportion of each type of pair configuration in PVC. (auth)

**32607** SYMMETRY SPLITTING OF EQUIVALENT SITES IN OXIDE CRYSTALS AND RELATED MECHANICAL EFFECTS. J. B. Wachtman, Jr., H. S. Peiser, and E. P. Levine. J. Res. Natl. Bur. Std., 67A: 281-9(July-Aug. 1963).

Changes in the symmetry of a crystal caused by an applied strain were used to show in what circumstances an internal friction peak can result from the motion of isolated point defects. General rules are given to make the prediction, and these are applied to several structures of common oxides. The prediction for rutile is compared with experimental results which are interpreted by the movement of titanium ions between interstitial positions in the structure. (auth)

**32608** EFFECT OF LESS COMMON METAL ADDITION UPON ALUMINUM ALLOYS OF 2S, 52S AND 61S TYPE. Takahashi Naoaki and Mishima Yoshitsugu. Light Metals, 12: 24-9(May 1962). (In Japanese)

The effects of the addition of Ta, V, Y, and Hf on the elongation, surface condition, workability, strength, corrosion resistance, stress corrosion sensitivity, and Vickers hardness number of 2S, 52S, and 61S type Al alloys were determined. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32609** PRACTICAL EXPERIENCES WITH THE 31 Mev BETATRON. H. Luling and H. U. Rychen. Materialpruefung, 4: 157-66(May 20, 1962). (In German)

The design and operation of a radiographic testing plant, using a 31-Mev betatron, for nondestructive testing of heavy metal parts including cast 12 to 13% Cr steel parts are described. The analysis of image quality as compared to $Co^{60}$ radiation and intensity compensation was made using Pb and Ta amplifier foils. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32610** PHYSICS AND TECHNOLOGY OF A PORTABLE 18 Mev BETATRON USED IN MATERIALS TESTING. Paul Fries. Materialpruefung, 4: 174-9(May 20, 1962). (In German)

The physical characteristics, design, and use of a portable 18-Mev betatron in nondestructive materials testing are given, along with x-ray absorption data for steel. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32611** THE EFFECT OF SMALL BERYLLIUM CONTENTS ON THE RECRYSTALLIZATION OF HIGH-PURITY ALUMINUM (RAFFINAL). H. Hug and R. Bichsel. Metal Treat. Drop Forging, 29: 258-66(July 1962).

The effect of Be on the recrystallization of high purity Al by influencing the precipitation of dissolved Fe, which blocks the migration of lattice defects, was investigated. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32612** THE EFFECTS OF CARBON AND NITROGEN ON THE RECRYSTALLIZATION, THE WORKABILITY AND THE MECHANICAL PROPERTIES OF NIOBIUM. E. Erben and F. Sperner (W. C. Heraeus GmbH, Hanau, Ger.). Metall, 17: 694-8(July 1963). (In German)

Investigations were made of Nb–C–N systems with C and N contents of up to about 1000 ppm. In addition the recrystallization behavior and the cold workability, as well as the mechanical properties were determined. Systems up to 60 ppm C and about 150 ppm N are single-phased, and systems with higher C and N contents have two or more phases. The recrystallization, with increasing C and N contents, was displaced to higher temperatures; while at the same time the secondary grain growth was strongly inhibited by the precipitation of secondary phases. Nb–C–N systems with 250 ppm C and N could still be cold worked well, systems with 500 ppm C and N began partly to crack during cold working, and systems with C and N contents greater than 500 ppm could no longer be formed cold. The mechanical properties were also changed strongly with increasing C and N contents. While the tensile strength was doubled, the breaking elongation in the recrystallized state decreased from 15 to 25 to 10 to 15%. (tr-auth)

**32613** THE USE OF INTERMEDIATE STRAIN RATES TO STUDY CREEP CAVITATION IN MAGNOX A12. S. J. Tyler and V. N. Whittaker (Coll. of Advanced Tech., Birmingham, Eng.). Metallurgia, 68: 17-22(July 1963).

An intermediate strain rate of 14.5% per hour was chosen to study the incidence of cavitation at various stages of the resultant load-extension curve, and also the effect of grain size on the percentage elongation measured in these tests. Although there is little justification for predicting creep behavior from these intermediate rate tests, it is felt that such tests provide a fairly rapid means of studying various effects associated with cavitation. (auth)

**32614** HIGH-TEMPERATURE MECHANICAL PROPERTIES OF URANIUM CARBIDE AND BERYLLIUM OXIDE. R. Chang, G. G. Bentle, and F. E. Ekstrom (Atomics International, Canoga Park, Calif.). Metals Eng. Quart., 3: 36-42(May 1963).

The high-temperature flow characteristics of polycrystalline U carbide and Be oxide are compared and discussed with regard to the possible importance of crystal structure, stoichiometry, and purity of the materials. The mechanism of flow for polycrystalline U carbide (and Ti

carbide) is that of the climb of dislocations. The flow behavior of fine-grained polycrystalline Be oxide (and Al oxide) is at present not entirely understood but may possibly be controlled by a diffusional mechanism. The current status of the preparation of high-purity U carbide and Be oxide is described. (TCO)

**32615** INVESTIGATION OF SUPERCONDUCTING $Nb_3Sn$. F. Lange. Monatsber. Deut. Akad. Wiss. Berlin, 4: 457-9(1962). (In German)

Specimens of $Nb_3Sn$ were produced by sintering from 900 to 1100°C in He or an He–Ne gas mixture. Superconductive characteristics, including critical field strength and critical current, were investigated. (Rev. Metal Lit., 20: No. 1, Jan. 1963)

**32616** STUDIES IN THE SYSTEMS THORIUM–MOLYBDENUM–CARBON AND URANIUM–MOLYBDENUM–CARBON. E. Rudy and F. Benesovsky (Metallwerk Plansee AG, Reutte/Tirol, Austria). Monatsh. Chem., 94: 85-98 (1963). (In German)

X-ray and metallographic studies were made on pressure-sintered, vacuum-annealed and arc-melted alloys in the ternary systems Th–Mo–C and U–Mo–C, and a distribution of the phase fields at 1400 and 1600°F (900°C) respectively, was undertaken. With the exception of $U_2C_3$, the known phases in the boundary systems, as well as the ternary crystalline substance $UMoC_2$, can be confirmed. In the system Th–Mo–C the equilibria Mo–ThC, $Mo_2C$–ThC, $Mo_2C$–$ThC_2$, and $Mo_3C_2$–$ThC_2$ occur. The reciprocal solubilities are limited; ternary compounds are not formed. At the metal-rich end of the U–Mo–C system the equilibria UC–γ-(U,Mo) (32 at. %, a = 4.36Å) and UC–Mo occur, whereas the carbon-rich end is dominated by $UMoC_2$ (equilibria: $UMoC_2$–C, –$UC_2$, –UC, –$Mo_3C_2$, –$Mo_2C$). A newly discovered crystalline compound of the approximate composition $UMo_3C_2$ has a metastable character and decomposes on melting to $UMoC_2$ and Mo. The reciprocal metal exchange in the carbon phases is slight. The cubic high-temperature form of $Mo_3C_2$ can be maintained in metastable equilibrium at room temperature by means of small amounts of U and Th (<1 at. %). Equilibria appearing in the systems U–Mo(W)–C and Th–Mo(W)–C were evaluated thermodynamically and limiting values are given for the free energies of formation of the compounds $UMoC_2$, $UWC_2$, and $ThC_2$. The stability of the dicarbides of U and Th is discussed. (tr-auth)

**32617** CONTRIBUTION TO THE STUDY OF THE STABILITY OF URANIUM DICARBIDE AND THE CARBON-STABLE REGIONS IN THE PARTIAL SYSTEMS OF UC WITH ZrC, HfC, NbC AND TaC. E. Rudy and F. Benesovsky (Metallwerk Plansee AG, Reutte/Tirol, Austria). Monatsh. Chem., 94: 204-24(1963). (In German)

At temperatures below 1600°C $UC_2$ gradually decomposes into UC and C. Under the selected conditions, the phase $U_2C_3$ cannot be detected in the decomposition products. The C-stable regions in the series UC–Zr(Hf, Nb, Ta)C extend at 1600°C almost over the whole mixed crystal region and become smaller at higher temperatures. In contrast with previous measurements it was found that the formation of the dicarbide from monocarbide and C proceeds endothermically. The free enthalpies of reaction for the reaction $UC + C \rightarrow UC_{1+x}$ (x = 0.80 to 0.90), calculated from the phase field distribution, amount to $\Delta G_R(cal) = 9620 - 5.25 \times T$ (1800 to 2500°K), whereas an adjustment of the values, taking into account the transformation of the dicarbide of 1820°C, gives the equations $\Delta G_R(cal) = 10350 - 5.57 \times T$ (2100 to 2300°K) and $\Delta G_R(cal) = 7710 - 4.31 \times T$ (1900 to 2100°K). Both the phase field distributions in the individual systems calculated from the mean values and the decomposition temperature of about 1550°C for UC, extrapolated using the temperature dependence of $\Delta G_R$, agree well with the experimental results. Further possibilities for calculating thermochemical data still outstanding for high-melting U and Th compounds are discussed. (tr-auth)

**32618** INTERSTITIAL SOLID SOLUTIONS IN BODY-CENTERED CUBE METALS. J. Stringer and A. R. Rosenfield (Univ. of Liverpool, Eng.). Nature, 199: 337-9 (July 27, 1963).

Activation energy for self-diffusion, oxygen solubility, and diffusion in bcc metal crystals are discussed. (P.C.H.)

**32619** PHASE CHANGE AND HEAT TREATMENT OF U–Mo ALLOYS. Kō Soeno (Hitachi Ltd., [Japan]). Nippon Genshiryoku Gakkaishi, 5: 475-80(June 1963). (In Japanese)

A series of uranium alloys varying in molybdenum content from 0.25 to 1.0 at. % was studied. The retention of β or γ uranium phase by quenching was examined as a function of molybdenum content. The β phase can be retained, while the retention of the γ phase and evidence of γ-to-α transformation could not be observed at all. The kinetics of isothermal transformation of β-to-α uranium was studied. From such results, it is difficult to deduce the existence of two modes of the transformation, martensitic, and nucleation-and-growth type, but such a problem is solved by examining microstructures produced in isothermal transformation and $M_s$ temperatures are determined. (auth)

**32620** EXPERIMENTAL STUDY ON MECHANICAL STRENGTH OF FUEL CLADDING TUBE UNDER THE LOSS OF COOLANT ACCIDENT. Nippon Genshiryoku Gakkaishi, 5: 508-17(June 1963). (In Japanese)

The objects of this study are to verify the behavior of the fuel cladding tube under the loss of coolant accident and to correlate the result with the mechanical properties of the tube materials. AISI 304L, 347 stainless steel, and Zircaloy-2 were selected for test cladding materials. The study consists of four sections as follows: analysis of the loss of coolant accident for PWR and BWR, and the determination of the experimental conditions; tensile test of cladding materials at high temperature and at the various moderate load rates; high temperature burst test of the various size cladding tubes; and dynamic burst test realizing the condition of the loss of coolant accident. It is concluded from a series of the experiments that the strength of the cladding tube is scarcely affected with a load rate such as the pressure decreasing rate in the loss of coolant accident, and it is possible to estimate the bursting pressure of the fuel cladding tube from the tensile results. (auth)

**32621** STUDIES ON HIGH TEMPERATURE OXIDATION AND MECHANICAL PROPERTIES OF Zr–Al AND Zr–Mo BASE TERNARY ALLOYS. Shigeo Aoki (Furukawa Electric Co. Ltd., Tokyo). Nippon Kinzoku Gakkaishi, 27: 212-16(1963). (In Japanese)

The high-temperature oxidation and the mechanical properties of Zr-base ternary alloys shown below were investigated: Zr–0.5% Al–1.5% Fe; Zr–0.5% Al–1.5% Cr; Zr–0.5% Al–1.5% Ni; Zr–1.0% Mo–1.0% Fe; Zr–1.0% Mo–1.0% Cr; and Zr–1.0% Mo–1.0% Ni. The oxidation was carried out in dry air at the temperature range of 500 to 700°C. The mechanical properties were measured at room temperature to 600°C. The results obtained were summarized as follows: (1) The rates of the oxidation of alloys containing Al are very high and the exponent n in the oxidation process is nearly 1. The reactions follow a liner

rate law. (2) In cases of alloys containing Mo, these rates are low and the exponent n is approximately 3, so that the cubic rate law may be applied. (3) The oxidation resistance of Zircaloy-2 in air is not so good. The exponent n is nearly 1 except in the initial period of the oxidation at 500°C. (4) The mechanical strength of alloys containing Al are stronger than these of alloys containing Mo. The strength of Zircaloy-2 at the elevated temperature is the lowest. (auth)

**32622** MAGNETIC STRUCTURES IN THE MnSb–CrSb SYSTEM. W. J. Takei, D. E. Cox, and G. Shirane (Westinghouse Electric Corp., Pittsburgh). Phys. Rev. 129: 2008-18(Mar. 1, 1963). (CONF-31-1)

A magnetic and neutron diffraction investigation was made on MnSb, CrSb, and their solid solutions, which crystallize in the hexagonal NiAs-type structure. MnSb is ferromagnetic and CrSb antiferromagnetic. As CrSb is substituted into MnSb, a canted spin structure is formed, the spins lying within ferromagnetic (001) sheets with the spins in adjacent sheets alternating in direction. The angle of cant increases with increasing Cr content in agreement with the model of de Gennes who considered the effects of double exchange on an antiferromagnetic system. The magnetic structure of CrSb consists of ferromagnetic (001) planes that are coupled antiferromagnetically. The spin axis is parallel to c. Between this structure and the canted spin structure with the spins perpendicular to c is an intermediate region. This antiferromagnetic region has either a tilted spin axis structure or two coexisting structures. MnSb was found to have a change in the spin direction from a perpendicular to a parallel orientation with respect to c as the temperature was increased. The temperature of the spin flip was found to depend on the preparative conditions as did the Curie temperature and saturation moment. (auth)

**32623** ZIRCONIUM ALLOY—A NEW ENGINEERING MATERIAL. Precision Metal Molding, 20: 37-8(Aug. 1962).

An investigation was made of the properties of Zircaloy-2 tubing produced by vacuum powder metallurgy including burst strength, ultimate strength, elongation, hardness, density, corrosion resistance, grain size, neutron cross section, gas content, and heat resistance. Consideration is also given to advantages of the powder metallurgy technique. (Rev. Metal Lit., 19: No. 11, Nov. 1962)

**32624** FORMATION OF CESIUM ANTIMONIDE. PART II. FORMATION OF $Cs_3Sb$ AT TEMPERATURES BELOW 130°C. Kiyoshi Miyake. Rev. Elec. Commun. Lab. (Tokyo), No. 5-6, 287-94(May-June 1961).

Films were prepared in a reaction tube at constant Cs pressure in the range from 28 to 130°C. The dependence of electric resistivity and photoresponse on the preparation temperature, temperature, and time, and activation energies were determined. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**32625** FORMATION OF CESIUM ANTIMONIDE. PART III. LOGARITHMIC GROWTH OF CESIUM ANTIMONIDE FILMS ON ANTIMONY. Kiyoshi Miyake. Rev. Elec. Commun. Lab. (Tokyo), No. 5-6, 295-9(May-June 1961).

Studies were made on the reaction of vacuum-evaporated films of Sb, and electrical measurements were made to determine the dependence of electric resistance on reaction time, thickness, and film growth rate. (TCO)

**32626** HEAT TREATMENT OF ZIRCONIUM RICH ALLOYS WITH NIOBIUM. Yataro Murakami and Toshio Enjyo. Tech. Rept. Eng. Res. Inst., Kyoto Univ., 12: 14p. (Feb. 1962). (In English)

Binary alloys of Zr (99 to 80%)–Nb(1 to 20%) were prepared in a tungsten arc furnace using a $H_2O$-cooled Cu crucible and purified Ar atmosphere. Measurements were made of dimensional and hardness changes of button alloy specimens at 250 to 1000°C. X-ray diffraction patterns of Zr–Nb alloys were determined. (Rev. Metal Lit., 19: No. 8, Aug. 1962)

**32627** EFFECT OF ZIRCONIUM ON AUSTENITIC GRAIN SIZE IN IRON AND STEEL. Akira Adachi and Kiyoshi Mizukawa. Tetsu To Hagane, 48: 683-7(Apr. 1962). (In Japanese)

Ferrozirconium was added to Fe and steel containing O, N, and C to study the effect of Zr nitride, oxide, carbide, and solid solutions on the austenitic grain size refining and coarsening temperature. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32628** EFFECT OF TITANIUM AND ZIRCONIUM ON THE HOT SHORTNESS OF LOW-MANGANESE STAINLESS STEELS FOR REACTOR MATERIALS. Masao Kawahata. Tetsu To Hagane, 48: 782-7(May 1962). (In Japanese)

The hot shortness of 347 stainless steel as affected by Ti and Zr content was investigated. (Rev. Metal Lit., 19: No. 8, Aug. 1962)

**32629** THERMAL CONDUCTIVITY OF CERTAIN A(III) AND B(V) COMPOUNDS. G. B. Abdulaev, G. M. Aliev, A. A. Bashshalliev, and I. G. Kerimov. Tr. Inst. Fiz., Akad. Nauk Azerb. SSR, 11: 46-51(1963). (In Russian)

Studies of InAs, GaAs, and GaSb thermal conductivity as function of temperature showed that at 20 to 180°C the GaAs thermal conductivity diminishes from $7.31 \times 10^{-3}$ to $3.82 \times 10^{-2}$ cal/cm sec°. Thermal conductivity of InAs diminishes with the rise of temperature reaching its minimum at 65°C. A diagram constructed of InAs, GaAs, and GaSb heat conductivity as a function of the mean atomic weight of the components at 20°C indicated diminishing thermal conductivity of specimens with the increase of atomic weight. Thermal electromotive force of examined specimens was measured at 90 to 325°C. (R.V.J.)

**32630** THERMODYNAMIC PROPERTIES AND LATTICE PARAMETERS OF HAFNIUM–OXYGEN ALLOYS. M. D. Silver (IBM Labs., Poughkeepsie, N. Y.), P. A. Farrar, and K. L. Komarek. Trans. AIME, 227: 876-84 (Aug. 1963).

Thermodynamic properties of Hf–O alloys are determined from 0 to 25 at. % O between 1000 and 1200°K by equilibrating specimens with alkaline metal oxide–metal vapor combinations. Partial molar-free energies, enthalpies, and entropies of oxygen are obtained and compared with similar results for the Ti–O and Zr–O systems. The positional entropy in all three systems corresponds to an ideal random interstitial solution with one interstitial site per one metal atom. The lattice parameters of hafnium and Hf–O solid solutions are determined in the range 0 to 20 at. % O from measurements of Debye powder patterns. (auth)

**32631** PREDICTING PHYSICAL PROPERTIES IN ORIENTED METALS. E. F. Sturcken and J. W. Croach (E. I. du Pont de Nemours and Co., Aiken, S. C.). Trans. AIME, 227: 934-40(Aug. 1963).

A grain orientation distribution function, $P(u,\phi)$, is developed for use in predicting physical properties in oriented metals. Examples are given of the use of the function to predict thermal expansion coefficients in rolled uranium rods and plate. The $P(u,\phi)$ function is synthesized

from x-ray diffraction intensity measurements, $I_i$, normally used to plot inverse pole figures. The symbols u and $\phi$ specify the angles that the crystallographic axes of the grain make with the normal to the sample surface and $P(u,\phi)$ gives the number of grains oriented in each direction $(u,\phi)$. $P(u,\phi)$ is obtained from a least squares fit of the $I_i$ to an orthonormal set of spherical harmonic functions. The $P(u,\phi)$ function is also used to define a quantity J, which is a measure of the departure of the orientation distribution from uniformity (or "randomness"). The J parameter may be used to follow, quantitatively, the amount of preferred orientation induced as a function of mechanical working or heat treatment. An example is given of the application of the J parameter to preferred orientation studies of hot- and cold-rolled uranium rods and hot-rolled uranium plate. Because $P(u,\phi)$ is derived from relative intensity measurements by the powder diffraction technique, it is applicable to material with large absorption coefficients and/or grain size and is particularly suitable for characterizing the preferred orientation of large numbers of samples such as fuel elements for a nuclear reactor. (auth)

**32632** DETERMINATION OF ALPHA ZIRCONIUM $\{11\bar{2}1\}$ TWINNING ELEMENTS USING GRAIN BOUNDARY ROTATIONS. R. E. Reed-Hill, W. A. Slippy, Jr., and L. J. Buteau (Univ. of Florida, Gainesville). Trans. AIME, 227: 976-9(Aug. 1963).

In $\alpha$ zirconium $\{11\bar{2}1\}$ twins tend to have coherent boundaries and thus do not usually taper to a point when they intersect a grain boundary. Under the proper conditions, a $\{11\bar{2}1\}$ twin may deform a boundary in such a manner as to clearly reveal the twinning shear. Measurements of these grain-boundary rotations yield a value of 0.63 for the $\{11\bar{2}1\}$ twinning shear. The magnitude of the observed shear and its shear sense are in excellent agreement with the assumption that the second undistorted plane ($K_2$) for this form of twinning is the basal plane (0002). (auth)

**32633** ACTIVITY COEFFICIENTS IN BINARY LIQUID METALLIC SOLUTIONS AT INFINITE DILUTION. John M. Dealy and Robert D. Pehlke (Univ. of Michigan, Ann Arbor). Trans. AIME, 227: 1030-2(Aug. 1963).

A tabulation is presented of the activity coefficients of infinitely dilute binary metal solutions at given temperatures. A method is shown for extrapolation of the data to temperatures other than those given in the tabulation. (T.F.H.)

**32634** THE SINTERING BEHAVIOUR AND STABILITY OF $(PuU)O_2$ SOLID SOLUTIONS. N. H. Brett and L. E. Russell (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram. Soc., 62: 97-118(Feb. 1963). (AERE-R-3900)

The sintering behavior and stability in Ar, $CO_2$, and H at 1400 and 1650°C of $(PuU)O_2$ solid solutions and the stability during arc-melting in Ar were studied. The solid solutions of $(PuU)O_2$ were prepared by calcining co-precipitates of $Pu(OH)_4$ and ammonium diuranate (A.D.U.). The calcination temperature that produced the maximum density in pellets sintered in H varied with composition from about 800°C for the $UO_2$-rich powders to about 400°C for the $PuO_2$-rich powders. Pellets prepared from $(PuU)O_2$ solid-solution powders generally sintered to a higher density in H than in Ar or $CO_2$ and pellets of 10 mole % $PuO_2$ had a higher density than those of $UO_2$ or 20 mole % $PuO_2$ sintered in a H atmosphere. Compositions in the range 0 to 20 mole % $PuO_2$ remained single-phase during H sintering and arc-melting, but compositions containing 40 mole % or more $PuO_2$, on cooling were transformed into two-phase mixtures, probably $(PuU)O_2$ and $UO_2-PuO_{1.62}$ solid solutions. The observations are supported by x-ray powder diffractometric and metallographic examinations and by determinations of the O/Pu + U ratio. (auth)

**32635** EFFECT ON URANIUM OXIDE OF CONTROLLING GRAIN GROWTH DURING SINTERING. C. A. Elyard, B. M. Gibbs, and H. Rawson (A.E.I. Research Lab., Rugby, Eng.). Trans. Brit. Ceram, Soc., 62: 127-37(Feb. 1963).

Experiments were carried out on $UO_2$ in which grain growth was suppressed by two methods: by adding to the $UO_2$ a small quantity of a finely divided second phase, namely Pt, and by sintering for prolonged periods at relatively low temperatures. The highest densities, approaching 10.9 g/cm$^3$, were obtained by sintering initially highly nonstoichiometric material for 70 hr at 1400°C in H. (TCO)

**32636** COMPRESSIVE CREEP AND SOME PHYSICAL PROPERTIES OF URANIUM MONOCARBIDE. J. J. Norreys and M. J. Wheeler (General Electric Co. Ltd., Wembley, Eng.). Trans. Brit. Ceram. Soc., 62: 183-7(Feb. 1963).

Preliminary compressive creep tests on UC and other U–C alloys show that the monocarbide creeps at a steady rate of 0.001%/hr at 1400°C and 5800 lb/in. Creep rates increase with C content up to 58 at. % C. The resistivity of UC rises from 40.5 $\mu\Omega$ cm at room temperature to 277 $\mu\Omega$ cm at 2252°K. The spectral emissivity falls from 0.67 at 1100°K to 0.47 at 1600°K and then remains constant at higher temperatures. (auth)

**32637** SYSTEMS OF UC, $UC_2$ AND UN WITH TRANSITION METALS. G. Briggs, J. Guha, J. Barta, and J. White (Univ. of Sheffield, Eng.). Trans. Brit. Ceram. Soc., 62 221-46(Mar. 1963).

The phase equilibrium relations in systems of UC, $UC_2$, and UN with Cr, Fe, and Ni were investigated. Powdered mixtures were cold-pressed to form pellets and heated in thoria crucibles in an atmosphere of purified Ar until equilibrium was reached, at temperatures between 1000 and 2000°C. The specimens were then cooled and examined metallographically and by x rays for phase identification. Solidus and liquidus temperatures were determined for selected compositions by metallographic examination of pellets that were fired at various temperatures. The systems UC–Cr, UC–Fe, UC–$Fe_2$, and UN–Fe were found to be of the simple eutectic type with no evidence of solid solubility. UC and Ni were found to be incompatible and the solid phase distribution in the ternary system U–Ni–C was established. In the system UN–Ni loss of Ni occurred with formation of $UNi_5$ at the N pressure prevailing during the experiments. In the $UC_2$–Fe system a compound $UFeC_2$ forms by a peritectic reaction between $UC_2$ and the liquid phase and forms a eutectic with Fe. Preliminary investigations suggest that the tie $UC_2$–Cr does not exist in the system U–Cr–C. Some thermodynamic considerations are also presented. (auth)

**32638** THE PLATINUM–NIOBIUM SYSTEM. Hirozo Kimura and Akira Ito. Trans. Natl. Res. Inst. Metals (Tokyo), 3: 27-34(1961).

An investigation of the Pt–Nb system was made by x-ray analysis, microscopic examination, and liquidus temperature determination. Data are given for solubility limits and lattice parameters of the resulting intermetallic compounds, $PtNb_2$ and $PtNb_3$. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32639** DETERMINATION OF MECHANICAL, CHEMICAL AND THERMIONIC PROPERTIES OF THORIATED TUNGSTEN. Petr Schneider. Vide, 17: 182-5(Mar.-Apr. 1962). (In French)

Thoriated W samples were subjected to graphite layer removal, carbonizing, and decarbonizing in hydrone and benzene vapor atmospheres at 2200°K, then they underwent mechanical property measurement at specified critical loading, quantitative chemical determination, and thermionic testing at 1900 to 2200°K at specified voltage and pressure, to study the amount of thoria and Th content, thermionic emission, mechanical properties, critical deflection, and weight changes. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32640** MAGNETIC PROPERTIES OF SCANDIUM SINGLE CRYSTALS. V. I. Chechernikov, Iuliu Pop, and O. P. Naumkin (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 44: 1826-8(June 1963). (In Russian)

The magnetic properties of a scandium single crystal obtained by recrystallization annealing are investigated. The magnetic susceptibility is measured in the temperature range from 77 to 1100°K. The susceptibility is greater in a direction parallel to the c axis than in the perpendicular direction. For both directions the paramagnetic Curie point is determined and found to be negative. (auth)

**32641** GALVANOMAGNETIC EFFECTS AND DEFORMATION OF THE ELECTRON SPECTRUM OF GRAPHITE UNDER PRESSURE. R. G. Arkhipov, V. V. Kechin, A. I. Likhter, and Yu. A. Pospelov (Inst. of Physics of High Pressures, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1964-73(June 1963). (In Russian)

By employing a certain energy spectrum of graphite and the relaxation-time approximation, a theory of the galvanomagnetic properties of graphite is developed and formulas are derived for the limiting case of high temperatures. An analysis of the experimental data on the dependence of the resistance, Hall coefficient, and magnetic resistance on temperature from room temperature to 150°C yields a simple relation between the relaxation time and temperature and the quasi-momentum. A quantity Q is defined, which is independent of temperature and only depends on the parameters of the energy spectrum. Up to pressures of 10,000 atm Q remains independent of temperature, and can be used for determining the dependence of the graphite energy spectrum parameters on the distance between the layers, on the basis of measurements of the resistance and galvanomagnetic coefficients as functions of pressure and temperature. Deformation of the energy spectrum of graphite under pressure can then be determined. At 10,000 atm the total number of carriers in graphite increases by 23%. At this pressure the relaxation time increases by 3%. (auth)

**32642** RADIOCHEMICAL AND ELECTROCHEMICAL STUDIES OF ELECTRODE PROCESSES ON AMALGAMS. G. M. Budov and V. V. Losev (Inst. of Electro-Chemistry, Academy of Sciences, USSR and Karpov Inst. of Physics and Chemistry, Academy of Sciences, USSR). Zh. Fiz. Khim., 37: 1230-5(June 1963). (In Russian)

Electrode processes on In and Tl amalgams in solutions of their perchlorates were investigated. In the case of Tl amalgams the rate of the process for all the concentrations studied was determined mainly by the rate of diffusion in the amalgam and in the solution. In the case of In amalgams the true rate of the anodic process depends linearly upon the potential within wide limits about the equilibrium potential value. The rate of the anodic process at constant potential is directly proportional to the amalgam concentration and is independent of the concentration of the solution. The rate of the cathodic process is directly proportional to the solution concentration. The transfer coefficients $\beta$ = 2.2 ± 0.07, $\alpha$ = 0.91 ± 0.02 were determined from the slopes of the true anodic and cathodic curves. The activation energy (12.8 kcal/mole) was calculated from the temperature dependence of the exchange current. Over the entire range of concentrations of amalgam and solutions studied the rate of the electrode process on the In amalgam was determined by the rate of the discharge-ionization stage. (auth)

**32643** ABSORPTION OF HYDROGEN BY CERIUM–MAGNESIUM ALLOYS. V. I. Mikheeva, Z. K. Sterlyadkina, A. I. Konstantinova, and O. N. Kryukova (Kurnakov Inst. of General and Inorganic Chemistry, Academy of Sciences, USSR). Zh. Neorgan. Khim., 8: 1314-19(June 1963). (In Russian)

Studies were made of hydrogen absorption by Ce–Mg alloys with 50 wt % Mg. A complete hydridation was reached with a higher Mg content. For 30 to 50% Mg the adsorption formula is $CeH_3 \cdot n\ MgH_2$ and in particular $MgH_2 \cdot 2\ CeH_3$ and $MgH_2 \cdot CeH_3$. Thermographic and chemical studies showed that the hydridation products are a mechanical mixture possessing different properties than those of $MgH_2$ and $CeH_3$. (R.V.J.)

**32644** SELECTION OF THERMOCOUPLES FOR HIGH GAS TEMPERATURE MEASUREMENT. D. J. Mackenzie and M. D. Scadron. Society of Automotive Engineers, 1962, Paper No. 524E, 6p.

Thermoelectric and mechanical properties of Pt, Ir, W, Re, and Rh used in thermocouples for measuring temperature of 1600 to 4000°F are given, along with resistivity of thermocouple insulating material such as beryllia, magnesia, and thoria. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32645** TENSILE PROPERTIES OF BERYLLIUM FROM ROOM TEMPERATURE TO 1600°F. W. J. Salmen and L. P. Gobble. Philadelphia, American Society for Testing Materials, 1962, Preprint No. 67, 12p.

Determinations were made of the modulus of elasticity, yield and ultimate strengths, and elongation of QMV Be blocks at room temperature to 1600°F using a strain rate of 0.005 in./in./min. The tensile properties and stress strain curves were analyzed as a function of temperature. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32646** MEASUREMENTS OF MAGNETIZATION OF GADOLINIUM NEAR THE CURIE POINT IN HIGH-PULSED FIELDS. H. Motz and C. S. Gaskell. p.561-7 of "High Magnetic Fields." New York, John Wiley and Sons, Inc., 1962.

Measurements were made on the magnetization of high purity Gd rods at 289°K as affected by magnetic field strength. (TCO)

**32647** SOME PHYSICAL PROPERTIES OF DEPOSITED $Nb_3Sn$. H. C. Hitchcock, P. R. Aron, G. D. Cody, and J. J. Hanak. p.592-6 of "High Magnetic Fields." New York, John Wiley and Sons, Inc., 1962.

Data are given for current-carrying capacity, lattice constant, density, transition temperature, electric resistivity, and other properties of gas-phase-deposited superconducting $Nb_3Sn$ coatings on refractory metal wire. (Rev. Metal Lit., 19: No. 8, Aug. 1962)

**32648** SPLAVY REDKOZEMEL'NYKH METALLOV. (Rare Earth Alloys). E. M. Savitskii, V. F. Terekhova, I. V. Burov, I. A. Markova, and O. P. Naumkin. Moscow, Publishing House of the Academy of Sciences, 1962. 268p.

Extensive experimental data are given on chemical and physical properties of yttrium, scandium, and their alloys. Constitution diagrams are constructed for binary and ternary systems, and alloying behavior was analyzed. Appli-

cations and use of rare earth metals in ferrous and nonferrous metallurgy and in nuclear techniques are also considered. The book is designed for engineers, scientists, and laboratory personnel. (R.V.J.)

**32649** THE EFFECT OF APPLIED STRESS ON THE GRAPHITIZATION OF PYROLYTIC GRAPHITE. R. H. Bragg, D. D. Crooks, R. W. Fenn, Jr., and M. L. Hammond (Lockheed Missiles and Space Co., Palo Alto, Calif.). 30p. (CONF-73-3).

From 6th Biennial Conference on Carbon, Pittsburgh, June 1963.

Metallographic and x-ray diffraction studies were made of the effect of applied stress at high temperature on the structure of pyrolytic graphite (PG). The dominant factor was whether the PG was above or below its graphitization temperature, which, in turn, was not strongly dependent on applied stress. Below the graphitization temperature, the PG showed a high proportion of disordered layers (0.9), a fairly large mean tilt angle (20°) and a small crystallite size ($L_a$ ~150 A). Fracture occurred at low stress and strain and the material exhibited a high apparent Young's modulus (~$4 \times 10^6$ psi). Above the graphitization temperature, graphitization was considerably enhanced by strain up to about 8%. The disorder parameter was decreased from a zero strain value of 0.3 to 0.15 with strain, the mean tilt angle was decreased to 4°, and a fivefold increase in crystallite size occurred. When the strain-enhanced graphitization was complete, the material exhibited a low apparent modulus (~$0.5 \times 10^6$ psi) and large plastic strains (>100%) for a constant stress (~55 ksi). Graphitization was shown to be a spontaneous process that is promoted by breaking cross-links thermally, and the process is furthered by chemical attack and plastic strain. (auth)

**32650** THE NIOBIUM–THORIUM EUTECTIC ALLOY AS A HIGH-FIELD, HIGH-CURRENT SUPERCONDUCTOR. H. E. Cline, R. M. Rose, and J. Wulff (Massachusetts Inst. of Tech., Cambridge). 15p. (CONF-35-2).

From American Physical Society, New England Section Spring Meeting, Cambridge, Mass., Mar. 1963.

Niobium-thorium eutectic alloys having fine acicular microstructures were produced by fast cooling from a vacuum melt. Although the solidified material was normal, continuity between the superconducting niobium-rich phase, which was essentially pure niobium, was attained by plastic deformation at room temperature. The resulting wire was tested for critical current at 4.2°K, in transverse magnetic fields up to 82.5 kilogauss; at the highest field, critical current densities of slightly more than $10^4$ amps per square centimeter were observed. The critical current density was independent of applied field from 20 kilogauss to the highest field used; the level of critical current density depended on diameter in a manner that suggested dependence on cold work. It was concluded that the cold work reduced the thickness of the needles of niobium below the superconducting penetration depth, and brought them sufficiently close together to allow the superconducting correlation to interconnect the niobium, in the manner suggested by Cooper; furthermore, the constant critical current region may possibly extend to considerably higher fields. (auth)

**32651** A MAGNETIC INVESTIGATION OF DILUTE SOLID SOLUTIONS OF 4f AND 3d TRANSITION METALS. Craig C. Kirkpatrick (Nuclear Corp. of America, Phoenix, Ariz.). 9p. (CONF-20-13)

From 3rd Rare Earth Conference, Clearwater, Fla., Apr. 1963.

The magnetic properties of dilute alloys of rare earth metals were investigated to determine the nature of the coupling that gives rise to ferromagnetic behavior in this class of materials. Alloy additions were made of iron, from the 3d group or of gadolinium, terbium, dysprosium, holmium, or erbium, from the 4f group. Susceptibility was measured by the Faraday technique. The magnetic properties of the iron alloys were found to vary with the electron concentration of the matrix, a behavior that was previously observed. The magnetic properties of the dilute rare earth alloys remained unchanged in similar matrices. Since the tightly bound 4f electrons must be localized under all circumstances, the observed coupling must be of the Ruderman-Kittel type. (auth)

**32652** THE PROPERTIES OF RARE EARTH NITRIDE SEMICONDUCTORS. N. Sclar (Du Mont Labs., Clifton, N. J.). 23p. (CONF-20-24)

From Rare Earth Conference, Clearwater, Fla., Apr. 1963.

The optical and electrical properties of the rare earth nitrides ScN, YN, DyN, HoN, and ErN were surveyed. From absorption edges found in the optical transmission curves, semiconductor energy gaps in the 2 ev range were determined as follows: DyN 2.1–2.9 ev; HoN 1.9–2.2 ev; ErN 2.4–2.8 ev. The spread in energies is due to differences observed in two experimental runs and to uncertainties in the choice of the absorption edge. For ScN and YN no definite absorption edge is indicated. The electrical properties at room temperature and up to 800°C for YN were found to be metallic with associated large concentrations of charge carriers. These results are interpreted to suggest that the present species of nitrides, which were all deficient in nitrogen content, are high-energy gap semiconductors, which are degenerate in the range of temperatures explored. The large concentrations of charge carriers are attributed to the lack of stoichiometry so far achieved. (auth)

**32653** INITIAL TEMPERATURES OF ZIRCONIA PHASE CHANGES AND SOLID-SOLUTION REACTIONS. Thomas W. Smoot and Joseph R. Ryan (Harbison-Walker Refractories Co., Pittsburgh). 18p. (CONF-50-10)

From American Ceramic Society, 65th Annual Meeting, Pittsburgh, Apr.-May 1963.

Mixtures of zirconia with yttria, magnesia, calcia, ceria, and combinations of calcia and magnesia were investigated by x-ray diffraction at temperatures up to 2870°F. The initial stabilizing reactions occurred at temperatures ranging between 900 and 2700°F. Magnesia apparently showed the lowest temperature of initial reaction; yttria the highest. Combinations of calcia and magnesia showed initial solid-solution at temperatures lower than calcia but higher than magnesia although magnesia seemed to be the first to react. Inconclusive evidence indicated that some exsolution occurred in some combinations when temperatures were lowered. (auth)

**32654** THE HEAT CAPACITY OF DYSPROSIUM METAL BETWEEN 3 AND 30°K. Howard E. Flotow and Darrell W. Osborne (Argonne National Lab., Ill.). 18p. (CONF-20-23)

From Rare Earth Conference, Clearwater, Fla., Apr. 1963.

The heat capacity of dysprosium metal has been reported by several investigators in the regions 0.4 to 4°K and 15 to 300°K. Since there is wide divergence of the results at 4°K and since there were no experimental results between 4 and 15°K the heat capacity of dysprosium was measured between 3 and 30°K. The sample was the one previously used

by Lounasmaa and Guenther for measurements from 0.4 to 4°K. The present heat capacity results agree within 2% with those of Lounasmaa and Guenther from 3 to 4°K and also agree within less than 1% with those of Griffel, Skochdopole, and Spedding from 15 to 30°K. No anomalous behavior in the heat capacity was observed between 3 and 30°K. The magnetic contribution to the heat capacity of dysprosium, $C_M$, was calculated between 4 and 30°K. The temperature dependence of $C_M$ below 20°K can be interpreted as the result of an energy gap of approximately 50°K at the minimum of the spin-wave spectrum. (auth)

**32655** INVESTIGATIONS INTO THE INFLUENCE OF GRAPHITIZATION-TIME AND -TEMPERATURE ON THE ASH CONTENT OF ELECTROGRAPHITE. E. Wege. 21p. (CONF-73-5)

From Biennial Conference on Carbon, Pittsburgh, June 1963.

The de-ashing of carbon bodies at higher temperatures was found to be relatively speedy procedure. Under equal conditions, after equal time periods, the ratio between momentary ash content and original ash content is constant, low final ash content means low original ash content. Since the ash content of the packing dust affects the graphitization system, it seemed possible to increase the de-ashing rate by the use of purex packing dust, or to decrease the de-ashing rate by the use of impure packing dust. Since the de-ashing speed is dependent on the temperature, small differences in the effective temperature will affect the ash content considerably. Thus, in order to prevent large differences in the final product as far as the ash content is concerned, it is suggested that the most uniform furnace temperatures be ensured. (P.C.H.)

**32656** A HIGH-TEMPERATURE REACTION IN THE $UO_2$–$TiO_2$ SYSTEM. L. M. Manojlovic, M. M. Ristic, and S. S. Malcic (Boris Kidric Inst. of Nuclear Sciences, Belgrad). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/54. 7p. (CONF-120-27). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

A new compound of U, with the composition $UO_2 + 3TiO_2$, was formed when $UO_2$–$TiO_2$ pressed powder mixtures of 5, 10, 20, 30, 40, 50, 60, 70, 80, and 90 wt % $TiO_2$ compositions were sintered in Ar at 1200, 1300, and 1400°C. (P.C.H.)

**32657** URANIUM-BASED CERMET ALLOYS. V. E. Ivanov, V. F. Zelenskii, A. I. Voloshchuk, and V. N. Grinyuk. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/69. 15p. (CONF-120-23). (In Russian)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Certain features of dispersion-hardened U-based cermets are described. As possible hardening materials, consideration was given to $UO_2$, UC, $Al_2O_3$, MgO, and $UBe_{13}$. Data were obtained on the behavior of U alloys containing the above-mentioned admixtures during creep tests, short-term strength tests, and cyclic thermal treatment. The corrosion resistance of $UBe_{13}$-based U alloys was also studied. (auth)

**32658** STUDY OF URANIUM DIOXIDE SINTERING IN THE LIGHT OF THE PINES THEORY. M. M. Ristic and E. Kostic (Boris Kidric Inst. of Nuclear Sciences, Belgrad). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/56. 12p. (CONF-120-17). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Changes in the characteristics of $UO_2$ were studied during sintering in an Ar atmosphere, and the results are interpreted in the light of the Pines theory. The diffusion coefficients of the pores, which disappear from the sintered samples, were determined from changes in sample density as a function of time and sintering temperature. The activation energy of 20.2 kcal/mole for the process was derived from the results. (auth)

**32659** ELECTRONIC STRUCTURE OF A SERIES OF METALS. W. A. Harrison (General Electric Research Lab., Schenectady, N. Y.). 39p. (CONF-58-2; 63-RL-(3322M))

From American Physical Society Meeting, St. Louis, Mar. 1963.

Self-consistent calculations of the electronic structure, including screened exchange, are carried out for Li, Be, Na, Mg, Al, K, and Ca. Results are presented as OPW form factors. They agree well with values of these form factors estimated from splittings at symmetry points in the Brillouin zones obtained from existing band calculations. For calcium, the form factors are used to compute the Fermi surface in detail. The computed form factor curves may be approximated within a few hundredth of a Rydberg by the Fourier transform of a simple one-parameter potential in which the core is replaced by a delta-function repulsive potential. There are no apparent trends in the strength of this repulsion with valence nor with atomic number. The familiar dropping of the even state at the zone face in the alkali metals as the atomic number increases is to be associated with the larger atomic volume rather than with changes in the core potential. An attempt to treat copper in a similar manner indicated that the form-factor approach is quite inadequate for the noble metals. (auth)

## Radiation Effects

*Refer also to abstracts 33253, 33264, and 33275.*

**32660** (BMI-1638) RADIATION STABILITY OF URANIUM MONONITRIDE. Richard A. Wullaert, John F. Lagedrost, Josef Bugl, and John E. Gates (Battelle Memorial Inst., Columbus, Ohio). June 28, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract W-7405-eng-92. 35p. (EURAEC-760)

Bare and stainless steel-clad isostatically hot-pressed uranium mononitride pellets were irradiated to burnups up to 3.8 at. % of the uranium at temperatures as high as 615 (surface) and 1260°C (center line) in NaK-filled capsules. The irradiation parameters were selected to permit an evaluation of the effect of both fuel burnup and hydrogen formation (from the $N^{14}(n,p)C^{14}$ reaction) on the stability of UN. Results of the irradiation indicated that hydrogen produced by the (n,p) reaction (~15 ppm) was not detrimental to the UN at these temperatures. Irradiated UN exhibited good dimensional stability, low fission gas release (<0.6%), and 25% increase in hardness. Only the most stringent temperatures and burnup conditions produced definite microstructural changes in the UN. Some grain growth occurred, and a white second phase precipitated near the UN-cladding interface. There was no attack of the UN by NaK during irradiation. In general, uranium mononitride showed excellent radiation stability. (auth)

**32661** (CRDC-1143) THE THERMAL CONDUCTIVITY OF $UO_2$ UNDER IRRADIATION: SOME EARLY RESULTS.

R. C. Hawkings and J. A. L. Robertson (Atomic Energy of Canada Ltd., Chalk River, Ont.). Mar. 1963. 114p. (AECL-1733)

Two series of experiments were previously performed to study the release of fission product gas from $UO_2$ during irradiation. Since the specimens contained central thermocouples, the observations can be analyzed to yield conclusions about the thermal conductivity of $UO_2$. Those aspects of the experimental method and results that relate to the thermal performance are described. Calculation of the relative neutron flux from observed quantities is discussed. In the second series a continuously operating flux monitor operated close to the specimen. It is shown that at low temperatures the thermal conductivity of $UO_2$ being irradiated is lower than that of unirradiated material. The damage appears to be confined to temperatures below approximately 700°C. Up to $2.8 \times 10^{20}$ n/cm$^2$ in natural $UO_2$ the effect of increased exposure is to reduce the conductivity in the low-temperature region to a limiting value of about 0.035 w/cm °C. (auth)

**32662** (CRFD-1132) STAINLESS STEEL SHEATHED $UO_2$ FUEL ELEMENTS IRRADIATED IN THE X-7 ORGANIC LOOP (COMMISSIONING AND ZIRCONIUM ALLOY FEASIBILITY TESTS). R. D. MacDonald, A. G. Cracknell, D. E. Lew, K. G. Heal, and D. H. Charlesworth (Atomic Energy of Canada Ltd., Chalk River, Ont.). Dec. 1962. 52p. (AECL-1762; EXP-NRX-5707)

The X-7 organic loop of the NRX reactor was successfully commissioned by irradiating nine stainless-steel-sheathed $UO_2$ fuel elements to a maximum burnup of about 1450 Mwd/ton U. The loop conditions and coolant chemistry for the tests are reported. The sheath thermocouples all failed early in the test irradiation, while the bulk coolant thermocouples with enclosed junctions operated satisfactorily. All elements were covered with an organic fouling film whose thickness and appearance seemed to vary with sheath temperature. Dimensions of the elements did not change from pre-irradiation values. The behavior of the $UO_2$ was consistent with other Chalk River tests at similar heat ratings. (auth)

**32663** (GEAP-3833) THE POST-IRRADIATION EXAMINATION OF A $PuO_2$–$UO_2$ FAST REACTOR FUEL. J. M. Gerhart (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). Nov. 1961. Contract AT(04-3)-189. 119p.

A program was carried out to determine the irradiation behavior of a $PuO_2$–$UO_2$ fast reactor fuel prototype. Forty stainless steel clad fuel specimens were fabricated, encapsulated, and irradiated in the General Electric Test Reactor to burnups ranging from 5000 to 99,000 MWD/T, and at heat fluxes ranging from $0.5 \times 10^6$ to $1.6 \times 10^6$ Btu/hr-ft$^2$. The cladding surface temperature ranged from 700 to 1200°F with most specimens in the 1000 to 1200°F range. All specimens were irradiated without rupture despite the high performance conditions imposed. Following irradiation, the fuel specimens were examined in the Radioactive Materials Laboratory. The post-irradiation examination consisted of dimensional measurements, gamma scans, determination of fission gas release, visual examination of the fuel, measurement of central voids, and metallographic examination of selected samples. Specimen and capsule fabrication is discussed, and the results of the post-irradiation examination are presented and discussed. (auth)

**32664** (GEAP-4197) $UO_2$ SWAGED POWDER FUEL ROD FAILURES AT HIGH THERMAL PERFORMANCE CONDITIONS. Preliminary Results. M. F. Lyons, R. C. Nelson, B. Weidenbaum, and T. J. Pashos (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Mar. 1, 1963. Work performed under United States–Euratom Joint Research and Development Program. Contract AT(04-31-189). 36p. (EURAEC-606)

The initial two irradiations of Euratom Program fuel assemblies containing compacted powder fuel rods resulted in fuel rod failures during GETR startup. The first failure occurred on December 20, 1962, when the reactor power rise from 20 to 25 Mw was initiated. The failure was found to be a longitudinal split in the cladding of the maximum power rod in the assembly, approximately $^3/_4$ of an in. long and 5 in. from the bottom end of the rod. The calculated peak surface heat flux in this rod, 4 in. above the point of failure, was 720,000 Btu/hr-ft$^2$. These initial 4 rods in the assembly were all Zircaloy-2 clad, arc-fused $UO_2$, vibrated and swaged to a density of 90.5%. Two rods from the assembly, including the failed rod, were replaced by similar $UO_2$ powder rods fabricated to 86% density by vibratory compaction alone. The replacement assembly was inserted in the PWL for startup on January 6, 1963. Again a failure occurred during startup, this time when the reactor power rise from 25 to 27 Mw was initiated. The failure again occurred in the higher power, swaged powder fuel rod. Its calculated peak surface heat flux at the time of failure was approximately 750,000 Btu/hr-ft$^2$. Both swaged rods experienced clad swelling and could not be removed from the assembly. Both vibratory compacted rods appeared satisfactory with no clad swelling. The higher power, vibratory compacted rod attained a peak surface heat flux in excess of 800,000 Btu/hr-ft$^2$ during the startup. The currently available results from the examination of these two failures are described and the preliminary conclusions concerning the failure mechanism presented. (auth)

**32665** (HW-74955) EFFECTS OF COLD WORK AND NEUTRON IRRADIATION ON THE TENSILE PROPERTIES OF ZIRCALOY-2. A. L. Bement, Jr. (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Apr. 1963. Contract AT(45-1)-1350. 194p.

An investigation was made of the effects of cold work and neutron irradiation on the plastic behavior and fracture mechanisms of Zircaloy-2. Tensile tests of annealed and cold-rolled Zircaloy-2 both before irradiation and after fast neutron exposures at about 60°C to $10^{19}$, $10^{20}$, and $10^{21}$ neutrons/cm$^2$ (n/cm$^2$) were conducted. Specimens were taken both from the transverse and rolling directions of sheet containing 0, 10, 20, 40, and 70% cold work. The preferred orientations imparted by cold rolling were characterized by x-ray diffraction pole figures. The results of this investigation showed that anisotropy in the tensile properties of Zircaloy-2 with stress direction is due to the inhomogeneity of plastic deformation. Plastic deformation occurred both by slip and twinning, and the amount of twinning varied with stress direction in accordance with preferred orientation. Directional effects were also observed both in the plastic instability associated with necking and in fracture. After the onset of necking, microcracks formed at inclusions and opened into pores. Porosity distributions depended on the confinement of plastic deformation during necking and inclusion distributions due to rolling. Transverse specimens necked primarily along shear zones and exhibited extensive shear lips in their fracture. The effects of preferred orientation on tensile properties were modified by neutron irradiation. Directionality effects on plastic instability were increased in annealed Zircaloy-2 by differences in radiation hardening mechanisms. Transverse specimens exhibited a yield point and necked at plastic strains less than 5% after exposures

of $10^{19}$ n/cm$^2$. This instability was accredited to the source hardening of twinning dislocations from neutron damage to the crystal lattice. Changes in tensile properties due to this type of hardening did not saturate at exposures less than $10^{21}$ n/cm$^2$, the highest exposure attained. Some strain hardenability in the longitudinal direction of annealed Zircaloy-2 was retained after neutron irradiation. Radiation damage impedance to moving dislocations had the major influence on properties in this direction. Changes in tensile properties saturated at about $10^{20}$ n/cm$^2$ exposure in longitudinal, cold-worked specimens. At higher exposures, reversals in strength and ductility were observed. This apparent recovery occurred at temperatures below the thermal recovery ranges for both cold work and radiation damage and was attributed to interactions between dislocations and radiation-induced defects. Twinning modes other than $\{10\bar{1}2\}$ twinning were not active in significant amounts after neutron irradiation. Variations in the inhomogeneity of deformation with stress direction were as dominant after irradiation as before. Modes of fracture and pore formation were unchanged by irradiation; however, deformation during necking in the transverse direction was more confined to shear zones. This greater confinement of necking deformation plus the decrease in strain hardenability accounted for a large decrease in fracture energy with irradiation. (auth)

**32666** (HW-77935) ANALYSIS OF BURNUP DATA FROM PRTR Pu–Al FUEL ELEMENT No. 5075. W. B. Henderson and F. G. Dawson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). June 18, 1963. Contract AT(45-1)-1350. 45p.

Burnup experiments are being performed in the Plutonium Recycle Test Reactor (PRTR) on modified fuel elements to obtain data useful in checking physics models in fuel cycle analyses. The irradiated element reported on is a standard Pu–Al PRTR element removed from the reactor because of a faulty end spider. The element is a 19-rod cluster of Pu–Al rods clad with Zircaloy. The element had received approximately 50 Mwd of exposure, which is approximately 20% burnup of the initial plutonium. The data obtained from the element, the laboratory procedures used, some of the difficulties encountered, comparison of the data with burnup calculations, and derivation of cross-section ratios from the data are discussed. (M.C.G.)

**32667** (HW-SA-2926) EFFECT OF MASSIVE NEUTRON EXPOSURE ON THE DISTORTION OF REACTOR GRAPHITE. J. W. Helm and J. M. Davidson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 28, 1963. Contract AT(45-1)-1350. 21p. (CONF-73-6)

From Biennial Conference on Carbon, Pittsburgh, June 1963.

Distortion of reactor-grade graphites was studied at varying neutron exposures ranging up to $14 \times 10^{21}$ neutrons per cm$^2$ (nvt)* at temperatures of irradiation ranging from 425 to 800°C. This exposure level corresponds to approximately 100,000 megawatt days per adjacent ton of fuel (Mwd/At) in a graphite-moderated reactor. A conventional-coke graphite, CSF, and two needle-coke graphites, NC-7 and NC-8, were studied. At all temperatures of irradiation the contraction rate of the samples cut parallel to the extrusion axis increased with increasing neutron exposure. For parallel samples the needle-coke graphites and the CSF graphite contracted approximately the same amount. In the transverse direction the rate of contraction at the higher irradiation temperatures appeared to be decreasing. Volume contractions derived from the linear contractions are discussed. (auth)

**32668** (NP-13019) ÉTUDE DE LA RECOMBINAISON RADIATIVE DES PORTEURS LIBRES PRODUITS PAR UN BOMBARDEMENT ÉLECTRONIQUE DANS LE SULFURE DE CADMIUM (THESES). (Study of the Radiative Recombination of Free Carriers Produced by Electron Bombardment in Cadmium Sulfide (thesis)). Gilles de Gaalon (Paris. Université). 1962. 30p.

The structure of the blue emission at the temperature of liquid nitrogen was studied using improved apparatus. The observations were carried to the temperature of liquid He in order to deduce the mechanism of the recombination of the free carriers. Before analysis of the light emitted by CdS single crystals exposed to electron bombardment and before a description of the experimental apparatus, the interaction of electron beams with the crystal and the resultant formation of free carriers are studied theoretically. The experimental study showed that the structure of the emission situated at the absorption limit, obtained by electron bombardment, does not differ basically from that observed under uv irradiation. However, the existence at 4°K of radiation (not observed with uv irradiation) with wave lengths less than 4.856 Å was shown. (J.S.R.)

**32669** (ORNL-3450) EMISSION SPECTRA OF ELECTRON IRRADIATED METAL FOILS. L. C. Emerson, E. T. Arakawa, R. H. Ritchie, and R. D. Birkhoff (Oak Ridge National Lab., Tenn.). Aug. 9, 1963. Contract W-7405-eng-26. 177p.

Thesis submitted to Univ. of Tennessee by L. C. Emerson.

An experimental investigation of the visible and ultraviolet light emitted when a charged particle moves across a boundary between two media with different dielectric properties was carried out. The spectral distributions of the light from evaporated foils of copper, germanium, silver, tin, and antimony bombarded by a 1.5-microamp beam of electrons were measured as a function of electron energy between 25 and 100 kev. The analysis was carried out with a Seya-Namioka vacuum ultraviolet spectrometer, Glan-Foucault prism polarizer, and a quartz-window photomultiplier. Calibration of the optical system with a NBS tungsten filament lamp enabled the intensity measurements to be carried out on an absolute basis. The experimental results for light polarized parallel to the plane containing the photon and the electron were compared with the calculated intensity of transition radiation, and in general the agreement was found to be excellent. The component of the photon intensity polarized perpendicular to this plane was compared with the calculated intensity of the optical portion of the bremsstrahlung spectrum. The predicted dependence on electron energy, photon wavelength, and foil thickness was observed although the measured yield was higher than that predicted by theory. The possibility of contributions from Cherenkov radiation and plasma radiation is also considered, but it is shown that it would be unlikely for these radiations to be observed under the experimental conditions of this study. (auth)

**32670** (ZFK-WF-21) ELEKTRONENMIKROSKOPISCHE METHODEN ZUR UNTERSUCHUNG REAKTORBESTRAHLTER $UO_2$ SINTERKÖRPER. (Electron Microscope Methods for Studying Reactor Irradiated $UO_2$ Sintered Pellets). Fritz Hilbert, Renate Krause, and Wolfgang Tzscheutschler (Germany. Zentralinstitut für Kernphysik, Dresden). July 1962. 14p.

Film replicas were taken from $UO_2$ pellets that become highly radioactive on reactor irradiation. These films were further prepared for the purposes of investigation in an electron microscope. The individual steps in the process are described, as is the comparative investigations of un-

treated, polished, and etched surfaces of the samples and of fractured surfaces. (auth)

**32671** (ZFK-WF-22) BEVORZUGTE BILDUNG VON ANIONENSTÖRSTELLEN BEI NIEDERENERGETISCHER BESTRAHLUNG VON ABVERBINDUNGEN, INSBESONDERE DIE BILDUNG VON FARBZENTREN IN IONENKRISTALLEN BEI RÖNTGENBESTRAHLUNG. (Favorable Building of Anion Defects by Low Energy Irradiation of AB-Compounds, Particularly the Building of Color Centers in Ion Crystals by Roentgen Irradiation). Manfred Balarin (Germany. Zentralinstitut für Kernphysik, Dresden). Nov. 1962. 29p.

Ideas about the mechanism for the building of radiation defects show that in ionic crystals there exists a favorable possibility for the creation of anion defects. This possibility acts especially when the applied radiation is only low energetic, for instance by $\gamma$ or electron irradiation. Therefore, the explanation of the experimentally observed creation of anion defects can be given without the use of the Varley mechanism. (auth)

**32672** DEGRADATION OF LUMINESCENCE IN NEUTRON-IRRADIATED GaAs DIODES. Marcella C. Petree (Naval Ordnance Lab., White Oak, Md.). Appl. Phys. Letters, 3: 67(Aug. 15, 1963).

Incoherent GaAs diodes were irradiated with neutrons to a maximum dose of $3 \times 10^{14}$ neutrons/cm$^2$ above 10 kev. The luminescence is profoundly degraded, whereas the current-voltage characteristics are not affected at room temperature. (R.E.U.)

**32673** MICROSTRUCTURE CHANGES IN ALPHA-IRON BY ION IRRADIATION. Max Hempel, Albert Kochendorfer, and Emil Hillnhagen. Arch. Eisenhuettenw., 33: 405-16(June 1962). (In German)

Ion irradiation at 20 to 250°C, with emphasis on N ions, of single crystal and polycrystalline alpha-Fe specimens containing 0.007 to 0.09% C, 0.003 to 0.30% Si, 0.0015 to 0.49% Mn, 0.017 to 0.024% P, 0.008 to 0.019% S, 0 to 0.02% Al, 0.004 to 0.01% Cr, 0.01 to 0.08% Cu, 0.004 to 0.005% N, 0.001 to 0.01% Ni, and 0.004 to 0.02% O was studied along with subsequent investigation of microstructure changes. The results are interpreted in terms of a diffusion model. (Rev. Metal Lit., 19: No. 11, Nov. 1962)

**32674** ON THE THEORY OF INTERACTION OF THE RADIATION WITH A SOLID. V. D. Kuchin (Machine-Building Inst., Zaporozhye, USSR). Bul. Inst. Politeh. Iasi, (N.S.), 8(XII): 97-106(1962). (In English)

Electromagnetic wave interactions with a solid are considered. Equations determining the displacement of an atom of the solid, the electrical conductivity of the solid, the inducing electromotive force, and the character of the temperature field in the irradiated solid are derived. (C.E.S.)

**32675** VESSEL GLASS FOR THE $\gamma$-RADIATION STERILIZATION OF MEDICINES. Yoichi (Yoiti) Chitani (Titan) and Yoshihide Naito (Tokyo Metropolitan Univ.). Doitai To Hoshasen, 4: 234-9(Sept. 1962).

A study was made on a total of 11 types of ampole, soft and hard chemical glasses irradiated by a $Co^{60}$ $\gamma$ source up to $2 \times 10^5$ r. An unpleasant brownish color can be avoided by adding 200 to 500 ppm of Mn into the ampole glass. Although the clear and transparent glass becomes purple and brown after irradiation, the brown color fades at a faster rate than the purple in room temperature. Hence, the glass becomes almost colorless or faintly purple. (TCO)

**32676** RADIATION-INDUCED GRAFT COPOLYMERIZATION TO CELLULOSE. II. GRAFTING OF STYRENE TO PRE-IRRADIATED VISCOSE RAYON YARN. Ichiro Sakurada, Toshio Okada, and Yoshihiko Hayashibe (Japanese Assn. for Radiation Research on Polymers, Osaka). Doitai To Hoshasen, 4: 240-7(Sept. 1962).

The effects of solvent, solvent/monomer ratio, addition of water to styrene solutions, pre-irradiation dosage, grafting temperature, and grafting time on the amount of styrene grafted to viscose rayon yarn were studied. Samples of 5 denier × 24 and a 1000-C $Co^{60}$ $\gamma$ source were used. It was observed that methanol was the best solvent for grafting, and the addition of a small amount of water to the styrene solution would accelerate the grafting remarkably. The optimum grafting temperature was about 50°C. Furthermore, the amount of styrene grafted to the viscose rayon yarn preirradiated in methanol was 2 times greater than that of yarn pre-irradiated in air. Preliminary experiments of grafting of methyl methacrylate were also carried out using a Van de Graaff electron accelerator as the radiation source. Measurements of the mechanical properties of the yarns showed that the elastic recovery at room temperature and the thermosetting properties were improved by grafting. (OID)

**32677** THE AGING OF HIGH POLYMERS WITH SPECIAL ATTENTION TO HIGH ENERGY RADIATION. M. Dyck. Farbe Lack, 68: 543-8(July 1962). (In German)

A review of effects of radiation on the aging process, and the stability of the chemical and physical structures of the high polymers with a macro-molecular structure are presented. The determination of the influence of temperature, humidity, and O content of atmosphere, and thermal, mechanical, electric, and chemical stress on the aging process are also discussed. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**32678** PROTON–NEUTRON DAMAGE CORRELATION IN SEMICONDUCTORS. J. R. Bilinski, E. H. Brooks, U. Cocca, and R. J. Maier (General Electric Co., Syracuse, N. Y.). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 20-6(July 1963).

The results of a study program to determine a proton-neutron damage correlation in semi-conductors are presented. The results of the theoretical studies show that damage processes between the neutrons and protons are basically different in silicon. Damage from neutron irradiation is characterized by the effective cross sectional area of the cluster of displaced atoms and is relatively independent of the type of impurity. Damage from protons, on the other hand, is dominated by the defects involving impurities. For this reason, theoretically derived damage cross sections for each different type of bombarding particle must be based on different physical properties of the semiconductor material. In the empirical study using the data from the literature, it was not possible to determine a reliable proton-neutron correlation. Spread in neutron damage data due to irradiation of different types of devices, inadequate data reporting and no data on similar type semiconductors under both neutron and proton irradiation contributed to this result. The experimental program was carried out on silicon solar cells under fission and moderated neutrons and proton energies of 48.5, 68.9, and 96.5 Mev. A proton-neutron correlation for the diffusion length damage was determined and the ratios of the proton to neutron damage varied from 0.6 to 4.8 depending on the proton energy and neutron spectrum. (auth)

**32679** RADIATION CHANGES METALS. Iron Age Metalworking Intern., 1: 32-4(June 1962).

The effects of fast neutron irradiation on the mechanical,

physical, corrosion, and thermal properties of carbon steels, stainless steels, low alloy steels, alloys, Al, and Ni, and various refractory metal alloys are discussed. (Rev. Metal Lit., 19: No. 8, Aug. 1962)

**32680** DEFECTS INTRODUCED IN NEUTRON-IRRADIATED ESAKI DIODES. C. B. Pierce and A. D. Kantz (Sandia Corp., Albuquerque, N. Mex.). J. Appl. Phys., 34: 1496-1503(May 1963). (TID-17277; SCR-608)

Ge and Si Esaki diodes have been subjected to reactor neutron irradiation at 90°K. Ge diodes show no structure in the radiation-induced excess current during irradiation but develop a hump at 0.30-v bias upon anneal to above 250°K, when observed at 77°K. In accordance with a model interpreting hump structure as being due to direct tunneling involving narrow defect levels deep in the forbidden band, the lack of structure in the as-irradiated Ge diodes is interpreted as being associated with a continuum of levels arising from clusters of defects. The growth of the hump (corresponding to an energy level at $E_v + 0.31$ ev) during anneal is associated with the breakup of large clusters into smaller defects, giving rise to a discrete energy level. Most of the continuum of added excess current (at bias values away from the hump), as well as the hump current, anneals out below 450°K. Anneal of the continuum agrees closely with recovery of length change in deuteron-bombarded Ge which has also been interpreted as being due to the breakup of clustered defects. Si diodes show hump structure at 0.3 and 0.6 v after irradiation and anneal to 195°K, upon observation at 77°K, and at 0.9 v in the course of further anneal. These humps are associated with energy levels at approximately $E_v + 0.35$, $E_c - 0.45$, and $E_c - 0.15$ ev, respectively. Hump structure and annealing behavior are quite similar to that observed after low-temperature electron irradiation, except that the structure is somewhat less distinct after neutron bombardment. According to the interpretation given the Ge results, this implies that large clustered defects in neutron-irradiated Si must have already partially annealed below 195°K or are relatively less numerous or less evident in their effects than in Ge. (auth)

**32681** ELECTRON MICROSCOPIC OBSERVATION OF DISLOCATION NETWORKS AND RADIATION DAMAGE IN α-URANIUM. E. Ruedl and S. Amelinckx (Studiecentrum voor Kernenergie, Mol, Belg.). J. Nucl. Mater., 9: 116-19 (June 1963). (In English)

Thin foils of α-uranium were prepared for transmission electron microscopy by electropolishing. Prior to final thinning the specimens were annealed in vacuo at 550°C for 1 hr. This resulted in a polygonized structure characterized by the frequent occurrence of well developed networks. It was found that occasionally hexagonal networks lying in the c-plane show dissociated nodes, proving that the stacking fault energy is rather small. The basis for the interpretation of the observations is discussed. Damage in the foils by neutron irradiation was observed as rows of small dots, which have a pronounced crystallographic orientation. (P.C.H.)

**32682** FURTHER NMR STUDIES OF POLYDIMETHYLSILOXANES: EFFECTS OF RADIATION-INDUCED CROSSLINKING. C. M. Huggins, L. E. St. Pierre, and A. M. Bueche (General Electric Research Lab., Schenectady, N.Y.). J. Polymer Sci., Pt. A, 1: 2731-9(Aug. 1963).

Previous nuclear magnetic resonance measurements on a polymethylsiloxane gum (Mw = 75,000) were interpreted to indicate the presence of considerable segmental motion in both the amorphous and crystalline components at temperatures above the glass temperature. Further investigation again showed the NMR line to be completely narrowed just above the glass point indicating such motions must extend into the crystalline component. Measurements were made of NMR absorption line widths for temperatures of 80 to 300°K on samples of the same gum subjected to gradually increased crosslinking by electron doses of 3 to $600 \times 10^6$ rep. Here, no change in the NMR properties of low temperature, rigid states was observed, but the room temperature line width progressively increased from 0.019 gauss to over 0.100 gauss peak-to-peak owing to the increase in bulk viscosity of the liquid. The first-order activation energy associated with the temperature-dependent line narrowing decreased from 10 to 2 kcal/mole. The NMR data indicate that the primary effects of radioinduced crosslinking are to reduce the chain rotational energy by the creation of defects and to increase the short-range viscosity by the lowering of translational freedom. (auth)

**32683** RADIATION VS. MATERIALS. PART 2. Edward J. Rohrbach and Howard S. Goldstein. Machine Design, 34: 148-50(Nov. 8, 1962).

The effects of irradiation on the mechanical and magnetic properties of metals and on the optical properties of organic materials are reviewed, along with the effects of ionization, irradiation, environment, and composition on the physical properties of plastics and elastomers. Radiation tolerance limits for various materials are also discussed. (TCO)

**32684** EFFECT OF ENERGY IRRADIATION ON THE PLASTIC DEFORMATION OF METALS. Erich Schmid. Materialpruefung, 4: 274-83(Aug. 10, 1962). (In German)

The effects of energy absorption by corpuscular irradiation or ultrasonics on the fatigue strength and toughness characteristics of monocrystalline and polycrystalline Zn, Cu, Ag, U, Al, Zr, carbon steel, Cr–Ni steel and Mn–Si steel whiskers are discussed. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**32685** SOME EFFECTS OF ELECTRON IRRADIATION ON THE YOUNG'S MODULUS OF GRAPHITE. P. R. Goggin (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Nature, 199: 367-8(July 27, 1963). (AERE-R-4364)

The effects of electron irradiation at 4 Mev on changes in the Young's modulus of pure pile graphite were studied. In all specimens measured there was no initial change in Young's modulus following the irradiation. On annealing, Young's modulus remained constant until a temperature of about 200°K was reached. Above this temperature there was a sharp inverse annealing peak with a maximum about 270°K. The height of the peak was found to vary as the square of the initial resistance change. As the irradiation dose was increased, the anomalous rise set in at a lower temperature and the peak developed a plateau on the high-temperature side. It coincided exactly with the inverse annealing peak observed in the annealing of thermal resistivity. (P.C.H.)

**32686** THE IRRADIATION OF SINTERED URANIUM OXIDE TO HIGH BURN-UP. J. B. Ainscough (United Kingdom Atomic Energy Authority, Springfield, Lancs, Eng.). Nucl. Eng., 8: 272-7(Aug. 1963).

Information available from the U.S.A. on the irradiation of $UO_2$ to burn-ups above about 15000 MW d/t is surveyed. Experiments on pellet rods, capsule irradiations, and examination of a fuel rod from the PWR first core at the end of the second seed life are reviewed. (R.E.U.)

**32687** THE EFFECT OF RADIATION ON CHARGED GLASS TUBES. Kakuji Yamamoto (Tokyo Metropolitan Isotope Center). Oyo Butsuri, 31: 357-9(May 1962).

An effective method to prevent the electrostatic charge

resulting from liquid flow in glass tubes is described. Tests were conducted by irradiating test tubes (7.8 mm in diam and 150 mm long; glass components in wt % of 75-$SiO_2$, 15.35-$B_2O_3$, 7.13-$K_2O$, 2.5-$Al_2O_3$, and 0.03-$Fe_2O_3$) filled with 10 $m_l$ commercially available cyclohexane from a 1-kC source of $Co^{60}$ at the rate of $3.48 \times 10^2$ r/hr up to dosage levels of $8.70 \times 10^2$, $28.18 \times 10^2$, $56.03 \times 10^2$, and $83.87 \times 10^2$ r at around 18°C. The results of the measured electrostatic charge generated in glass tubes vs volume, its maximum value vs total radiation dosage, and irradiation induced charges are discussed. It was concluded that the induced electrostatic charge decreases when the dosage exceeds a certain level. (OID)

**32688** THE OXIDATION OF GRAPHITE. I. THE OBSERVATION OF OXIDATION ON SYNTHETIC GRAPHITE BEFORE AND AFTER IRRADIATION. I. M. Dawson and E. A. C. Follett (Glasgow Univ.). Proc. Roy. Soc. (London), Ser. A, 274: 386-94(July 30, 1963).

Ultra-thin sections of a synthetic graphite were examined in the electron microscope before and after oxidation in air at a temperature of 500°C. In unirradiated material, micrographs of individual areas showed that oxidative attack occurred at grain boundaries and at pores between individual crystallites. Parallel experiments on material that had been irradiated to a dose of $8.7 \times 10^{19}$ n.v.t. again showed etching at pores and at grain boundaries, but, in addition, in the majority of specimens, a shallow surface pitting of the entire (0001) faces of the individual crystallites took place. The density of these shallow pits varied from $5 \times 10^{10}/cm^2$ to $5 \times 10^{11}/cm^2$. Variations in reaction rate were observed and were traced to impurity which, especially appeared to be absorbed only at pores and intercrystallite boundaries, oxidation effects being observed only at these sites. In irradiated material impurity was also absorbed at sites on the (0001) crystal faces where oxidation produced etch pits of widely varying depth and density. Channelling of the (0001) layer nets occurred in both irradiated and unirradiated specimens. Annealing of the irradiated graphite at 650°C for 1 h produced no significant change in the pattern of attack by oxygen. The observed etch pit density measured on the (0001) layer nets was $8 \times 10^{10}$ $cm^2$. A mechanism for pit formation relating pit density and vacancy content is proposed. The general appearance of irradiated samples differed from the unirradiated in that the well-defined moiré patterns characteristic of thin sections of synthetic graphite were absent in irradiated samples, but reappeared when the samples were annealed at 650°C. This change is related to the known behavior of interstitial atoms in graphite on annealing the materials. (auth)

**32689** IRRADIATION DAMAGE IN URANIUM MONOCARBIDE. L. B. Griffiths (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram. Soc., 62: 189-95(1963).

Measurements of both electric resistivity and lattice parameter revealed that detectable radiation damage occurs in UC after short radiations and that the damage rapidly saturates. From annealing studies of both irradiated and quenched specimens, it was concluded that, in the main, interstitials are mobile in UC at about 100°C and vacancies at about 700°C. (TCO)

**32690** MICROSTRUCTURAL CHANGES PRODUCED IN URANIUM OXIDE DURING IRRADIATION AND UNDER THE INFLUENCE OF HIGH TEMPERATURE GRADIENTS. B. T. Bradbury (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram. Soc., 62: 159-70(Feb. 1963).

Sintered cylindrical pellets of $UO_2$ irradiated by neutrons at sufficiently high heat ratings showed marked changes in microstructure. The changes may be significant, particularly with respect to the release of gaseous fission products. (TCO)

**32691** THE IRRADIATION BEHAVIOUR OF MONOCARBIDE FUELS. B. R. T. Frost (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram. Soc., 62: 171-6(Feb. 1963).

The fission gas release characteristics of UC were studied by the light irradiation technique in England and in Canada and are shown to be similar to those found in $UO_2$. Basic studies of radiation damage processes and of annealing characteristics using several methods were also carried out. There appears to be a difference in behavior between arc-cast and reaction sintered UC, which is, as yet, unexplained. However, there appears to be general agreement that all damage is annealed out above 700°C. (TCO)

**32692** THE EFFECTS OF NEUTRON IRRADIATION ON THE MAGNETIC PROPERTIES OF FERROMAGNETIC BULK ALLOYS AND THIN FILMS. A. I. Schindler and C. M. Williams (Naval Research Lab., Washington, D. C.). 19p. (CONF-23-10)

From American Physical Society Meeting, St. Louis, Mar. 1963.

In order to ascertain the types and origins of the irradiation-induced modifications of the magnetic properties, toroid and thin film samples of selected permalloys, in various states of magnetization, were exposed to neutron irradiation. In-pile, as well as pre- and post-irradiation magnetic hysteresis loop and magnetic anisotropy measurements were made. The magnetic characteristics of the toroid samples were severely affected by the irradiation and exhibited increased values of the coercive force as well as large changes in hysteresis loop shape. Thin film samples of $Ni_3Fe$, on the other hand, had hysteresis loop characteristics that were much less affected by the neutron irradiation. However, following irradiation in a magnetic field applied in the hard direction, the magnetic anisotropy of the thin films was found to decrease significantly. These results are interpreted as arising from the development of radiation-enhanced short-range directional ordering as well as the interaction between the irradiation-induced defects and the magnetic domain structure. (auth)

**32693** EFFECTS OF SPACE RADIATION ON ORGANIC MATERIALS. J. G. Carroll and R. O. Bolt (California Research Corp., Richmond). 34p. (CONF-14-16)

From American Chemical Society National Meeting, Los Angeles, Mar.-Apr. 1963.

The influence of the space radiation on organic materials is estimated from the extensive test work available with radiation from nuclear reactors. The neutrons and gamma photons that predominate in reactor experiments have effects on organic matter similar to those of the protons and electrons found in space. A picture of the space radiation environment was obtained from current literature. The incident fluxes were then reduced to dose rates that organics might experience. Based on this information doses received in a space vehicle that escapes the earth's magnetic field are considerably below those that cause appreciable damage in organic materials. Thus, space radiation need not be a factor in selecting organics for use in such vehicles. However, this situation does not hold for satellite vehicles in selected earth orbits. Here, care will be necessary in selecting certain organic components. (auth)

**32694** PROPOSED STUDY OF THE VARIATION OF RADIATION DAMAGE WITH NEUTRON ENERGY. Daniel Binder (Hughes Aircraft Co., Fullerton, Calif.). 7p. (CONF-23-14)

From American Physical Society Meeting, St. Louis, Mar. 1963.

Atomic rearrangement effects produced by neutron irradiation of solids are studied. Variations of these effects with neutron energy are discussed, and it is proposed that calculations of this energy variation be carried out with a precision sufficient to make possible differentiation between the effects of fission and 1/E spectra. Effects on Ge, Zn, and Cu are discussed as examples. (T.F.H.)

**32695** FORMATION OF THIN POLYMER DIELECTRIC FILMS BY ULTRAVIOLET IRRADIATION OF SURFACES IN CONTACT WITH MONOMER VAPOR. L. V. Gregor and H. L. McGee (International Business Machines Corp., Yorktown Heights, N. Y.). 9p. (CONF-57-2)

From Electron Beam Symposium, Boston, Mar. 1963.

The results of an investigation on the process of thin polymer dielectric film formation by uv irradiation, particularly with respect to films derived from the monomers acrolein ($CH_2 = CH-CHO$), methyl methacrylate ($CH_2 = C(CH_3)-COOCH_3$), and divinylbenzene ($CH_2 = CH-C_6H_4-CH = CH_2$). Formation of the polymer film was studied by two different methods. The rate of film deposition is proportional to the partial pressure of monomer up to several mm Hg, and then approaches a constant value. The dielectric constant of the film is approximately that of the bulk polymer, but the dissipation factor is somewhat higher and tends to increase with increasing film thickness. (P.C.H.)

**32696** CHARGED PARTICLE TRACKS IN GLASS. R. L. Fleischer and P. B. Price (General Electric Research Lab., Schenectady, N. Y.). 5p. (CONF-23-3; 63-RL-3266M)

From American Physical Society Meeting, St. Louis, Mar. 1963.

Heavily ionizing particles passing through crystalline solids produce trails of damage that can be seen either directly by electron microscopy or indirectly, by means of preferential chemical dissolution of the damaged material. Where both methods were used, it was shown that the method of chemical attack is the more sensitive. This method of revealing irradiation effects is able also to display the paths of heavy particles in a great many noncrystalline materials, in this instance glass. It is shown that fission fragments from $Cf^{252}$ leave damage trails in glass that may be etched to give conical pits. In some glasses the cone angles are small, so that the direction taken by the moving particles may be followed. Fission tracks can also be revealed in certain glasses by preferential precipitation of a metal such as silver along the damaged regions. This method has the advantage that a track does not have to intersect a free surface to be revealed. (auth)

**32697** MEASUREMENT OF METAL CREEP UNDER FAST NEUTRON IRRADIATION IN A REACTOR. J. Pefhany (Hawker Siddeley Canada Ltd., Canada). 14p. (CONF-82-1)

From Canadian Nuclear Association Conference on Heavy Water Reactors, Ottawa, May 1962.

A facility was developed for determining the creep rate of Zircaloy-2 in a fast neutron field at high temperatures. Results are presented of the tests of the facility and of runs on Zircaloy-2 inserts in the NRX reactor. The results indicate that the in-reactor creep rate is higher than the out-of-reactor rate. (D.L.C.)

**32698** DIRECT MEASUREMENT OF THE THERMAL CONDUCTIVITY OF URANIUM OXIDE IN-PILE UP TO 1200°C. R. Caillat, R. Delmas, J. C. Janvier, J. A. L. Robertson, and M. Bogaievski (CEN, Saclay and Grenoble, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/10. 24p. (CONF-120-8). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Two elements with thick stainless steel cans having two thermocouples in the uranium oxide and one in the can wall were irradiated at an increasing power intensity in the EL3. Temperature readings taken under different stable operating conditions provided a curve of variations in the apparent conductivity of the sintered uranium oxide between 200 and 1200°C. (auth)

**32699** LABORATORY FOR THE STUDY OF SPACE RADIATION EFFECTS. John E. Duberg and Emanuel Rind (Langley Research Center, Hampton, Va.). 16p. (CONF-94-2)

From American Nuclear Society Meeting, Nuclear Materials for Space Applications, Cincinnati, Apr. 1963.

A laboratory is being constructed for studying the effects of space particulate radiation on space vehicle systems and for research in high-energy physics. A brief summary is given of the present knowledge of flux and energy level of protons, solar flares, and electrons in space. It was decided to use a CERN-type synchrocyclotron, a Dynamitron, and an electron linac for simulating the space radiation environment. The design layout of the laboratory and equipment is described. Finally, the proposed research program is described briefly. (D.L.C.)

**32700** PROMOTION OF HIGH ENERGY RADIATION EFFECTS IN POLYMERIC MATERIALS. Herbert R. Anderson, Jr. (to Phillips Petroleum Co.). U. S. Patent 3,098,808. July 23, 1963. Filed Apr. 14, 1958.

A method is described for increasing the effects of $\alpha$, $\beta$, $\gamma$, or x rays upon long-chain polymers, either natural or synthetic, by associating therewith a promoting material. The promoting material incorporated into the polymeric material can be a heavy metal having an atomic number of at least 40, an organometal in which the metal component has an atomic number of at least 30 and preferably 40 or more, or a metal salt of a saturated or unsaturated aliphatic acid having from 8 to 30 or more carbon atoms per molecule. The metal can be incorporated into the polymeric material either in its free state or as an alloy or compound; it should be in a finely divided form. Benefits can also be realized by encasing films or sheets of polymeric material between thin plates of metal so that firm contact is maintained between surfaces during irradiation. An extrusion apparatus for continuously irradiating a polymeric filament and a similar apparatus in the form of a roll mill for pressing sheet are described. Twelve examples of the process are presented. (A.G.W.)

# PHYSICS

## General and Miscellaneous

*Refer also to abstract 32646.*

**32701** (AERE-R-4341) FARADAY EFFECT IN SEMICONDUCTORS. I. M. Boswarva (United Kingdom Atomic Energy Authority. Research Group. Atomic Energy Research Establishment, Harwell, Berks, England). May 1963. 142p.

The general macroscopic and quantum mechanical formulas necessary to calculate the Faraday rotation in semiconductors are reviewed. Dispersion relations between Faraday rotation and absorption coefficient are derived, and it is shown how these rotations can be used to introduce damping phenomenologically. The general formulas are then applied to calculate Faraday rotation caused by allowed direct band-to-band transitions, forbidden direct transitions, indirect phonon-assisted transitions between a pair of simple bands. The Faraday rotation due to direct allowed transitions near $\underset{\sim}{k} = 0$ in semiconductors whose valence-band structure can be represented by the Luttinger-Kohn model is analyzed. Specific computations were performed to find the interband Faraday rotation in Ge, GaAs, InSb, InAs, and GaSb using effective mass parameters and other band constants, previously determined by other workers. Discrepancies between theory and experiment are discussed in terms of inadequacies in the band model; contributions to the rotation from other types of transitions, in particular zone-edge transitions; and inaccuracies in the band parameters used. The agreement between theory and experiment is best for those substances for which the rotation varies monotonically with frequency, that is GaAs and InSb. However, this model also predicts qualitatively the unusual behavior of Ge and GaSb in which the rotation is positive at low frequencies, passes through a maximum and then tends to infinity negatively as the frequency approaches the absorption edge. 84 references. (auth)

**32702** (ASD-TDR-63-442) THE DEVELOPMENT OF AN AUXILIARY ELECTRODE THERMIONIC CONVERTER. W. B. Hall and J. J. O'Grady (Radio Corp. of America. Electron Tube Div., Lancaster, Penna.). Feb. 1963. Contract AF33(657)-8005. 200p.

Work accomplished to improve efficiency and life expectancy of thermionic energy converters for space applications is described. A converter was developed which employed an emitter thermally bonded to, but electrically insulated from, a central heat source tubing suitable for liquid metal. Power levels in excess of one watt per square centimeter were obtained at an operating temperature of 1200°C with an efficiency of 5%. As a result of studies performed during the program, converters can now be designed which employ only materials compatible with cesium for greater reliability and longer life. Improved performance and series operation of converters on a liquid-metal loop were demonstrated. (auth)

**32703** (BNL-795) PROPERTIES OF QUADRUPOLE MAGNET DOUBLETS. W. F. Baker (Brookhaven National Lab., Upton, N. Y.). May 1963. Contract [AT(30-2)-Gen-16]. 45p. (BNL-T-304)

The optical properties of the quadrupole doublet were calculated on a computer using the thick lens, linear theory. Lateral magnifications, field gradients, reduced focal lengths, reduced angular acceptances, and reduced acceptance solid angles are given for the double-focusing condition and the condition yielding a parallel beam. (D.C.W.)

**32704** (BNL-6916) THEORY OF ELECTRON EMISSION WIDTHS. Nazakat Ullah (Brookhaven National Lab., Upton, N. Y.). [nd]. Contract [AT(30-2)-Gen-16]. 20p. (CONF-46-27)

From American Physical Society Meeting, Washington, D. C., April 1963.

An expression for the reduced width of an auto-ionizing level was derived using the R-matrix theory. The electron emission widths were calculated as a function of channel radius. By choosing an appropriate value of channel radius it was found that the electron emission width is $5.885 \times 10^{-3}$ ev for an outgoing p electron of kinetic energy 1.162 ev. This width is about 3000 times larger than the partial radiation width of the level. It is shown that certain selection rules cause some of the partial widths to vanish. Thus measurements can provide very useful information about the type of coupling. The electronic radial wave functions were obtained by a self-consistent-field calculation. The calculation also showed that the penetrability is not too sensitive to the change in atomic electrical polarizability and the core radius. (auth)

**32705** (BSD-TDR-63-102) KRAMERS' AND LINE RADIATION FROM NITROGEN AND AIR SHOCKS. R. A. Allen, R. L. Taylor, and A. Textoris (Avco Corp. Avco-Everett Research Lab., Everett, Mass.). May 1963. Contracts DA-19-020-ORD-5476 and AF04(694)-33. 20p. (AMP-113)

Radiation data obtained from both the nonequilibrium and equilibrium regions behind normal shocks in the velocity range from 7 to 12 mm/$\mu$ sec using the recently developed electric arc-driven shock tube are presented. Atomic line radiation is a prominent feature of both the nonequilibrium and equilibrium regions of strong air and nitrogen shocks at wavelengths longer than 0.6$\mu$. For the higher end of this velocity range, molecular band radiation from air is negligible compared to the continuum radiation produced by the capture and the deceleration of electrons (Kramers' radiation). Measurements of this continuum were made and are found to be in good agreement with theoretical predictions based on calculations performed by Biberman and Norman for the free-bound radiation from nitrogen. Farther in the infrared from 2–8$\mu$, radiation measurements were made behind reflected shocks in air and nitrogen at equilibrium temperatures of 6000 to 9000°K. This continuum radiation is interpreted as due to free-free scattering of electrons from neutral atoms and molecules. An analysis of the data using the classical Kramers' radiation formula resulted in establishing the "effective coulombic charge," Z, for $N_2$, N, and O, and indicates that in air the bulk of the free-free radiation is due to nitrogen atoms and molecules, with oxygen giving a negligible contribution. (auth)

**32706** (CONF-23-19) SUPERCONDUCTIVITY AND LOCALIZED MAGNETIC STATES IN Ti–Mn ALLOYS. J. A. Cape (Atomics International. Div. of North American Aviation, Inc., Canoga Park, Calif.). May 28, 1963. Contract [AT(11-1)-Gen-8]. 31p.

From American Physical Society Meeting, St. Louis, Mo., Mar. 1963.

Evidence for superconductivity and for localized magnetic states in the dilute hexagonal close-packed (hcp) alloys of Ti–Mn was given previously. Detailed studies are described which indicate that the superconductivity observed previously in the dilute (1 to 5 at. % Mn) alloys was due to retained enriched bcc inclusions and not proper to the hcp matrix itself. Curie-Weiss susceptibility behavior is observed in dilute (0.2–4 at. %) Ti–Mn confirming the existence of localized magnetic states in the hcp phase. The magnitude of the Curie constant (typically $\approx 10^{-4}$ emu/g) suggests that magnetic moments ($\mu \approx 3.5\mu_B$/atom) are localized at the sites of Mn atoms in the hcp ($\alpha$ or $\alpha'$) phases of the alloys. No Curie-Weiss behavior is observed in body-centered cubic (bcc) ($\beta$) Ti–Mn. Annealing and quenching techniques were employed to prepare single phase hcp specimens and two-phase specimens consisting of bcc filaments in an hcp matrix. The former are not superconducting down to 1°K; the latter have zero resistance at the temperature coinciding with the $T_c$ of bulk bcc specimens. It is concluded that localized magnetic states suppress superconductivity in hcp Ti–Mn, while in the bcc phase $T_c$ is elevated commensurately with expected changes in the electronic state density N(O). In consequence, the existing experimental evidence on this system should not be interpreted in support of a magnetic-interaction hypothesis for superconductivity. 40 references. (auth)

**32707** (CONF-46-43)' EXCITATION OF THE $N_2^+$ FIRST NEGATIVE SYSTEM IN THE BOMBARDMENT OF $N_2$ BY $N_2^+$ OF A FEW kev ENERGY. John P. Doering (Los Alamos Scientific Lab., N. Mex.). Apr. 16, 1963. Contract W-7405-eng-36. 19p.

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Progress is reported on studies of optical excitation by charge transfer in atmospheric gases. The bombardment of nitrogen gas by nitrogen molecular ions of a few kev energy is described. The mechanism of excitation of 3914 Å (0,0) $N_2^+$ first negative emission was studied. Results are shown on graphs. Spectra taken of $N_2$ excited by various other ions are also included. (M.C.G.)

**32708** (D1-82-0254) THE INTERACTION OF MOVING SOURCE CURRENTS WITH A HYDROMAGNETIC FLUID. Richard A. Gerwin (Boeing Scientific Research Labs., Seattle). Apr. 1963. 22p.

An incompressible fluid of finite conductivity is assumed to be permeated by a uniform magnetic field. The field of an arbitrarily oriented, weak magnetic dipole moving along the direction of the uniform field is calculated. The results reduce to those of others in the limit of no uniform field sufficiently far from the source. The main result is that the far field of the dipole (the field outside of the wake) is the vacuum dipole field times the factor $(1-u^2/\alpha^2)^{-1}$, where u is dipole speed and $\alpha$ is Alfven speed. In fact, a general theorem is proved: neglecting mechanically induced disturbances, the magnetic field of an arbitrary (small strength) d-c current configuration moving along the uniform field lines with speed u is its vacuum value times $(1-u^2/\alpha^2)^{-1}$, outside of the wake. It is also shown that an accurate treatment of the problem, when source speed is close to Alfven speed, requires the inclusion of displacement currents. (auth)

**32709** (IFA/SN/17) RAZELE $\gamma$ ORDONATE DUPA ENERGII EMISE DE RADIOIZOTOPII FORMATI PRIN ACTIVAREA CU NEUTRONI TERMICI A IZOTOPILOR NATURALI. ($\gamma$ Rays Arranged According to the Energy Emitted by Radioisotopes Formed by Thermal Neutron Activation of Natural Isotopes). V. Cojocaru (Academia R.P.R. Institutul de Fizică Atomică, Bucharest). 1962. 36p.

The $\gamma$ rays emitted by radioisotopes produced in the thermal neutron activation of natural isotopes are tabulated according to energy. The natural abundance of the isotope, its half life, thermal neutron cross section, and absolute intensity of the radiation are given. The source of each energy tabulation is given. 91 references. (J.S.R.)

**32710** (JÜL-123-PP) UNTERSUCHUNGEN ÜBER DIE REPRODUZIERBARKEIT DER LICHTEMISSION EINER GLEITFUNKENSTRECKE IM HOCHVAKUUM. (Study on the Reproducibility of Light Emission from a Sliding Spark Gap in High Vacuum). H. Conrads and H. Hartwig (Kernforschungsanlage. Institut für Plasmaphysik, Jülich, Germany). Apr. 1963. 17p.

In a vacuum sliding spark the periodic structure of the discharge and the reproducibility of the light emission were investigated with the help of rotary reflection photograph and photoelectric measurements. By the use of suitable insulator materials, a reproducible light emission could be achieved. Rotation-reflection photographs of the electrode surface caused the ignition not by a sliding discharge but by field emission to be explained. (tr-auth)

**32711** (LNF-62/113) CALCOLI DI SEZIONI D'URTO PER PRODUZIONE DI COPPIE DA FOTONI LINEARMENTE POLARIZZATI, IN CRISTALLI. (Calculation of the Cross Section for the Production of Pairs from Linearly Polarized Photons in Crystals). Note No. 113. G. Barbiellini and G. Bologna (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Dec. 20, 1962. 17p.

The equation for the differential cross section in the Born approximation for the production of electron pairs in the field of a nucleon by linearly polarized photons, in the high energy and small angle approximation, was simplified by the introduction of four variables that express the arguments of the Dirac functions and thus simplify the integration. (J.S.R.)

**32712** (LNF-63/26) I MAGNETI SUPERCONDUTTORI. (Superconducting Magnets). Note No. 195. G. Pasotti, N. Sacchetti, G. Sacerdoti, and G. Sanna (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Apr. 23, 1963. 15p.

Hard superconductors are defined, and the possibility of constructing high field magnets is discussed. In the hard superconductors, the Meissner effect is not evident and the induction is not zero at their core. The critical field is very high, with a critical current of the order of $10^5$ amp/cm$^2$. Experimental results on materials used for the construction of such magnets are summarized and show that the best materials are $Mo_3Re$, $Nb_3Sn$, and Nb–Zr with a maximum Zr concentration between 65 and 75%. The construction of superconducting coils is described. The experimental results on solenoids of Nb–Zr with various Zr percentages are tabulated. Phenomena limiting the operation of superconducting solenoids are described, and the residual fields of the coils were measured. (J.S.R.)

**32713** (LNF-63/27) PRODUZIONE DI COPPIE DI ELETTRONI IN CONVERTITORI SPESSI PER ENERGIE DI ELETTRONI PRIMARI TRA 30 E 200 Mev. CALCOLO NUMERICO COL METODO MONTECARLO. (Production of Electron Pairs in Thick Converters for Primary Electron Energies Between 30 and 200 Mev. Numerical Calculation with the Monte Carlo Method). Note No. 196. E. Ferlenghi, M. A. Spano, and G. Verri (Italy. Comitato Nazionale per

l'Energia Nucleare. Laboratori Nazionali, Frascati). Apr. 26, 1963. 14p.

The optimum conditions for the positron beam at the exit of the converter were calculated by varying the energy of the electron beam on the target. The target thickness was assumed to be between 0.4 and 2 radiation lengths. The physical processes occurring and the criteria for the calculation are described. The formulas used are given, and the approximations introduced in the formulas are analyzed. The block diagram of the iterative method used in the calculation is presented. (J.S.R.)

**32714** (NP-12996) NRL QUARTERLY ON NUCLEAR SCIENCE AND TECHNOLOGY. Progress Report for the Period October–December 1962. (Naval Research Lab., Washington, D. C.). Jan. 1, 1963. 44p.

Developments in the quaternion approach to elementary particle theory, unitary Hilbert-space operator construction, measurement of oceanic cosmic and nuclear radiations, and decay activity measurement of $Cs^{137}$ and $Co^{60}$ half lives are reported. Separate abstracts were prepared for the five sections. (D.C.W.)

**32715** (NP-12996(p.1-22)) QUATERNION APPROACH TO ELEMENTARY PARTICLE THEORY. [PART] II. E. J. Schremp (Naval Research Lab., Washington, D. C.).

Three methods of setting up the same correspondence between certain non-singular complex quaternions, which are important in the quaternion approach to particle theory, and certain real proper orthochronous Lorentz matrices that may be interpreted in terms of elementary particles are described. The third method is used to examine the underlying theory of the relevant matrices. (D.C.W.)

**32716** (NP-12996(p.23-8)) BARYON DOUBLETS AND NEUTRINO DOUBLETS. [PART] II. E. J. Schremp (Naval Research Lab., Washington, D. C.).

Weyl's two-component spinor formulation of Dirac's electron theory is extended to obtain a quaternion formulation of the theory by which elementary particles of spin $\frac{1}{2}$ can be described. An 8-component Dirac wave function in $4 \times 2$ matrix form is derived in which the elements form the usual Dirac 4-component wave functions of the proton and the neutron. Thus, a quaternion description of the nucleon is obtained. Operations on the quaternion wave functions may be associated with particle processes (decomposition, etc.), and the matrix elements (and their signs) of the wave functions may be related to spin and isospin states of nucleons. Particle processes and properties are discussed in terms of the formulation. (D.C.W.)

**32717** (NP-12996(p.29-35)) THEOREMS FOR CONSTRUCTION OF EXPLICIT REPRESENTATIONS OF UNITARY OPERATORS IN QUANTUM FIELD THEORY. P. H. Moravek and D. W. Joseph (Naval Research Lab., Washington, D. C.).

A method for deriving unitary transformation operators in Hilbert space is presented. Division of operators into continuous and discrete categories is discussed, and three theorems for constructing unitary operators are proved. The theorems are used to derive unitary Hilbert-space operators for gauge transformations on Dirac fields, particle-antiparticle conjugation of Dirac fields and space inversion for Dirac fields as examples. (D.C.W.)

**32718** (NP-12996(p.36-7)) OBSERVATIONS OF NUCLEAR AND COSMIC RADIATION IN THE OCEAN. G. A. Burginyon, J. W. Butler, and W. H. Jones (Naval Research Lab., Washington, D. C.).

Nuclear and cosmic radiations as a function of depth were studied with the bathyscaphe Trieste off the California coast. The gamma-ray spectrum from decay of radioactive isotopes in the ocean was obtained with a NaI(Tl) crystal and showed peaks at 1.46, 1.8, 2.17, and 2.61 Mev. The 1.46 and 2.61 Mev peaks come from $K^{40}$ and $Tl^{208}$. By similar means the cosmic muon intensities at 0, 1284, and 1977 ft depths were determined to be 60.6, 0.068, and 0.066 counts/min. Cosmic neutron data obtained with a $BF_3$ proportional counter were deemed unreliable. (D.C.W.)

**32719** (NP-12996(p.38-42)) THE HALF-LIVES OF $Cs^{137}$ AND $Co^{60}$. S. G. Gorbics, A. E. Nash (Naval Research Lab., Washington, D. C.); and W. E. Kunz (Los Alamos Scientific Lab., N. Mex.).

The half lives of $Cs^{137}$ and $Co^{60}$ were measured by observing the decay of their activities over a three-year period. The apparatus and procedure used are described, and other determinations of these half lives are listed for comparison. Two runs were made for each isotope, and the average values derived were $29.68 \pm 0.05$ and $5.263 \pm 0.002$ yrs for $Cs^{137}$ and $Co^{60}$, respectively. (D.C.W.)

**32720** (NP-13004) HERMITICITY OF HAMILTONIANS AND EXISTENCE OF EIGENSTATES IN SOLUBLE FIELD THEORIES. Walter C. Henneberger (Dublin Inst. for Advanced Studies). [1962]. 12p.

The model in which a charged, elastically bound point electron interacts with the dipole part of the radiation field is studied within the framework of the new Tamm-Dancoff (NTD) method. It is shown that assumption of the existence of eigenstates forces the conclusion that the Hamiltonian is not hermitian. Since this behavior is shared by the Lee model when the coupling constant exceeds the critical value, the difficulties of the two models may well have a common origin. It is shown that, if imaginary values for energy differences are disregarded, the NTD method gives the same energy shifts and phase shifts as the method of transformation to normal coordinates. (auth)

**32721** (NYO-10423) ON THE USE OF DIATOMIC ORBITALS IN CALCULATIONS OF THE ELECTRONIC WAVE FUNCTIONS OF DIATOMIC MOLECULES. James W. Cooley (New York Univ., New York. Atomic Energy Commission Computing and Applied Mathematics Center). Sept. 1962. Contract [AT(30-1)-1480]. 32p.

It is suggested that the electronic wave functions of one electron in the field of two nuclei may, in some cases, provide a good basic set of one-electron orbitals for variational calculations of electronic wave functions of several-electron diatomic molecules. General formulas and computational methods for the necessary electronic energy integrals are discussed, and a machine program for calculating integrals appropriate to the homopolar diatomic molecule is described. (auth)

**32722** (PR-P-57) PHYSICS DIVISION PROGRESS REPORT, JANUARY 1–MARCH 31, 1963. (Atomic Energy of Canada Ltd. Chalk River Nuclear Labs., Chalk River, Ont.). 90p. (AECL-1778)

Progress in nuclear physics, theoretical physics, neutron physics, electronics, and general physics is reported. Separate abstracts were prepared for each of the five sections. (D.C.W.)

**32723** (PR-P-57(p.5-20)) NUCLEAR PHYSICS BRANCH. G. C. Hanna (Atomic Energy of Canada Ltd. Chalk River Nuclear Labs., Chalk River, Ont.).

A value for $\sigma_f$ of $Pu^{239}$ of $266 \pm 8$b for 2200 m/sec neutrons was obtained. Fine structure in the fragment yield of spontaneous $Cf^{252}$ fission was studied, and the kinetic energies of the fragments were compared with Whetstone's

values. Interpretation of neutron fission data and the influence of shells on the shape of fission fragments were investigated. The equilibrium yield of negative ions produced when C and O pass through H was found to have a maximum at particular energies. Coulomb excitation of levels by heavy ions was studied. The B(E2) ↓ for various levels in $Cu^{63}$ relative to that for a level in $Ni^{62}$ were determined. No evidence for an excited ($^3/_2^-$) level in $Cu^{63}$ could be found. Doppler shift measurements after Coulomb excitation gave lifetimes of $Cu^{63}$ and $Cu^{65}$ levels that were lower than those obtained by resonance fluorescence techniques. The spins and widths of levels in $Mg^{24}$ at excitations of 19–25 Mev were determined, as were the average level spacings as a function of spin in $Mg^{24}$ at about 25 Mev. An upper limit of $3 \times 10^{-4}$ was established for the ratio $\Gamma_\gamma/\Gamma$ for the 5.80-Mev level in $Ne^{20}$. Magnetic spectrometer measurements on the $C^{12}(C^{12},\alpha)Ne^{20}$ reaction revealed a new (5–) level at 8.46-Mev excitation in $Ne^{20}$. (D.C.W.)

**32724** (PR-P-57(p.21-36)) GENERAL PHYSICS BRANCH. H. Carmichael (Atomic Energy of Canada Ltd. Chalk River Nuclear Labs., Chalk River, Ont.).

Operation of the Sulfur Mountain neutron monitor is summarized, and testing and evaluation of the NM-64 neutron monitor is reported. The anomalous L subshell conversion line intensity ratios observed for highly hindered E1 transitions in heavy-odd nuclei were studied. Results indicate the anomaly is not directly proportional to the γ-ray retardation, and that for a given retardation the anomalies in odd-neutron nuclei are smaller than those in odd-proton nuclei. New conversion lines were observed in the decay of $Yb^{177}$. The widths of the atomic M states in Sm were determined to be: $M_I$ = 14 ev, $M_{II}$ = 4.7 ev, and $M_{III}$ = 7.7 ev. A Si p-n junction was used as the electron detector in measurements of the K170–γ203 and γ170–K203 angular correlations in $I^{127}$. The $A_2$ correlation coefficients were determined to be 0.058 ± 0.010 and 0.092 ± 0.014, respectively. Absolute counting techniques showed that (9.72 ± 0.15%) of the 28-day $Cr^{51}$ decays populate the 322-kev level in $V^{51}$. The K-shell fluorescence yield of Cu was measured to be 0.454 ± 0.008. Development of counters and semiconductor detectors is summarized. (D.C.W.)

**32725** (PR-P-57(p.37-43)) NEUTRON PHYSICS BRANCH. G. A. Bartholomew (Atomic Energy of Canada Ltd. Chalk River Nuclear Labs., Chalk River, Ont.).

The intensity of the one-phonon peak in the Landau excitation curve for liquid He was observed to become very small for large momentum transfers, in agreement with theory. The lattice dynamics of Nb were investigated. The frequencies of some modes and dispersion curves were obtained. A least squares fit to the data using Born-von Karman theory indicated strong electron-phonon interaction. Observation of coherent slow neutron scattering by pure gallium arsenide at 296°K with a triple axis crystal spectrometer was used to determine the frequencies of normal vibrational modes propagating in the [ξ 0 0], [ξ ξ ξ], and [0 ξ ξ] crystal directions. The frequencies are 5 to 10% lower than those for Ge. The spins of levels in $Ti^{49}$, $Cr^{51}$, $Cr^{53}$, $Fe^{55}$, $Fe^{57}$, $Ni^{59}$, $Cr^{54}$, and $S^{33}$ were determined from neutron capture γ-correlations. Correlation coefficients for transitions in the nuclei were also derived. Gamma scattering by $Al^{27}$ foils was studied. Resonance excitation in the foils was noted; the resonant scattering spectrum from 800 kev to 10 Mev was measured. (D.C.W.)

**32726** (PR-P-57(p.44-68)) ELECTRONICS BRANCH. P. R. Tunnicliffe (Atomic Energy of Canada Ltd. Chalk River Nuclear Labs., Chalk River, Ont.).

Developments in reactor instrumentation, pulse analyzing systems, automatic control and recording equipment, micrologic circuits, and various other circuits are reported. Exposure of Al and Au plated brass plates to gamma radiation showed the electron emission from Au to be five times that from Al. The electrical resistance of $UO_2$ exposed to a proton beam at an energy deposition rate of 6 watts/gm was observed to change only 0.1%. Hall effect measurements on stoichiometric $UO_2$ with magnetic fields up to 11,800 gauss gave a Hall coefficient of 0 ± 20 $cm^3$/Coulomb and an upper limit of Hall mobility of 0.026 $cm^2$/volt-sec. (D.C.W.)

**32727** (PR-P-57(p.69-85)) THEORETICAL PHYSICS BRANCH. H. H. Clayton (Atomic Energy of Canada Ltd. Chalk River Nuclear Labs., Chalk River, Ont.).

Simplified methods of calculating the effective cross sections in natural uranium fuel media to an accuracy of about 3% were developed. The analyses are being extended to take account of neutron energy losses and neutron sources in the fuel media. Four different methods of calculating nuclear properties are being exploited. For nuclei between $O^{16}$ and $Ne^{20}$, the negative parity low-lying states were studied using a model with LS coupling and a group theoretical method for classifying the states in order of decreasing symmetry. For $Cr^{52}$ and $Ca^{44}$, which have four nucleons outside a doubly magic core, j-j coupling calculations were carried out. For nuclei such as $Cu^{63}$ and $Au^{197}$, a model in which a $j = {}^3/_2$ particle or hole is coupled by a quadrupole force to a quadrupole vibrating spherical core is considered. Development of numerical methods for solving the many-nucleon dynamical equations continued. Statistical reaction theory was used in the analysis of experimental reaction data. The results show that in certain cases the inelastic scattering of neutrons can help determine s-, p-, and d-wave neutron strength functions. The focusing of charged particles by an axially symmetric magnetic field was studied. Some five theorems concerning charged particle orbits were established. The transmission for a $\sqrt{2}\pi$ spectrometer with a field varying as $\gamma^{-n}$ was calculated to be 2 or 3 times that of present Chalk River $\sqrt{2}\pi$ spectrometers. (auth)

**32728** (SC-4687(RR)) HEIGHT-OF-BURST EFFECTS ON LONG-RANGE PROPAGATED BLAST PRESSURES. Hugh W. Church (Sandia Corp., Albuquerque, N. Mex.). May 1962. Contract AT(29-1)-789. 20p.

Increasing height of burst above ground for high-explosive bursts is known to increase blast efficiency out to at least the 2-psi level. To determine whether this effect is carried out to large distances by atmospheric refraction, microbarograph measurements were made at 107 and 129 miles from eleven 6400-pound TNT shots fired at four heights of burst. Results indicate that apparent blast yield is about tripled by elevating the burst from ground surface to 2λ. (auth)

**32729** (SCR-636) INFRARED MODULATION BY FREE CARRIER ABSORPTION. R. B. McQuistan and J. W. Schultz (Honeywell Research Center, Hopkins, Minn.). June 1963. Contract [AT(29-1)-789]. 18p. (CONF-26-4)

From Optical Society of American Meeting, Jacksonville, Fla., March 1963.

At wavelengths beyond the fundamental absorption edge the transmittance of semiconducting materials may be altered by the injection of free minority carriers. Utilizing this phenomenon to modulate infrared radiation is discussed. Experimental results relating to the electro-optical characteristics of free carrier modulators are presented and compared with theory. (auth)

**32730** (TID-19116) COMPUTATION CURVES FOR AXI-SYMMETRIC BASE PRESSURE ANALYSIS. Glen W. Zumwalt and Homer H. Tang (Oklahoma State Univ., Stillwater. School of Mechanical Engineering). Mar. 1963. For Sandia Corp., Albuquerque, N. Mex. Contract AT(29-1)-789. 35p. (SCDC-3284)

Analyses are being made of base pressures under the highly transient conditions that occur when a supersonic missile flies through a blast wave. The computation method required solutions of the axi-symmetric base pressure to be found for successive time increments while the jet-mixing surfaces are acting as ejectors and the free stream conditions vary with time. The curves presented are applicable to turbulent, compressible jet mixing, where the total temperature is constant across the mixing region, and the flow streamlines converge conically. The principal parameter obtainable from these curves is the dimensionless velocity of the streamline which divides the free stream flow mass from the flow mass entrained from the "dead-air" near the base of the body. The conical pressure rise theory for separated flows was used in the calculation. (M.C.G.)

**32731** (TID-19137) PRODUCTION OF SLOW ELECTRONS AND POSITIVE IONS IN He, Ne, Ar, $H_2$, $N_2$, $O_2$ AND CO BY ENERGETIC HELIUM IONS. D. W. Martin, R. A. Langley, J. W. Hooper, D. S. Harmer, and E. W. McDaniel (Georgia Inst. of Tech., Atlanta). [1963]. Contract [AT(40-1)-2591]. 20p.

The apparent cross sections for the production of slow positive ions and free electrons for $He^+$ ions incident on He, Ne, Ar, $H_2$, $N_2$, $O_2$, and CO were measured in the energy range 0.133 to 1.0 Mev, and similar cross sections were measured for $He^{2+}$ ions incident on He and $H_2$ in the energy range 0.5 to 1.0 Mev. Direct comparisons were made with existing experimental results, including both total cross sections and charge changing cross sections. Comparisons were also made with available theoretical calculations and with results that are predicted from the Bethe-Born approximation with the evaluation of certain parameters from earlier proton measurements. It was shown that the $He^+$ ion was equivalent to a point-charge ion of effective charge 1.2 in high energy ionization. (auth)

**32732** (TID-19169) STUDIES OF $H_2^+$ DISSOCIATION. Phase III. Quarterly Progress Report No. 3, May 15, 1963 through August 14, 1963. A. W. Ehler (Hughes Research Labs. Div. of Hughes Aircraft Co., Malibu, Calif.). Aug. 12, 1963. Contract AT(04-3)-362. 7p.

Measurements on the dissociation of $H_2^+$ ions at one field strength showed that variations of the operating conditions of the Philip Ionization Gauge ion source had little effect on the dissociation fraction. Results obtained so far are discussed in relation to Sweetman's data. Reduction of the wire size in the dissociation chamber is noted to lead to an $H^+$ ion beam with an energy spectrum, only the more energetic part of which is collected by the electron multiplier. The electron multiplier was found to collect only 0.15 of the total $H_2^+$ ion current. (D.C.W.)

**32733** (UCRL-7314(Rev.I)) PRODUCTION OF TRANSURANIUM ELEMENTS IN A THERMONUCLEAR EXPLOSION — ANACOSTIA. R. W. Hoff and D. W. Dorn (California. Univ., Livermore Lawrence Radiation Lab.). May 8, 1963. Contract W-7405-eng-48. 9p. (CONF-72-3)

From Transplutonium Element Symposium, Argonne, Ill., May 1963.

A low-yield thermonuclear device was fired underground at the AEC Nevada Test Site as part of the Project Plowshare. Radiochemical analysis of the debris established the fact that elements at least through mass number A = 246 were formed. The plot of abundance versus mass number can be fitted assuming a single flux region of about $3 \times 10^{24}$ neutrons/cm$^2$. (auth)

**32734** (UCRL-7357) ELECTRODE SHEATH EFFECTS IN PULSED, HIGH CURRENT DISCHARGES. Charles W. Hartman (California. Univ., Livermore. Lawrence Radiation Lab.). June 13, 1963. Contract W-7405-eng-48. 20p. (CONF-75-3)

From Sixth International Symposium on Ionization Phenomena in Gases, Orsay, France, July 1963.

The effects of electrodes on the stability of high current ($I_{max} \approx 100$ ka, $\tau\,^1/_{4\,cyc} = 10$ μsec), pulsed discharges in deuterium (2–100 μ) were studied with the inverse stabilized hard-core pinch configuration. Subsequent to the initiation of the discharge by symmetrically arrayed spark triggers in the cathode, an erratic cathode sheath potential of 100–200 v develops as emission spreads over the cathode. Large sheath potential persists during increasing current and is accompanied by high frequency (0.1–1 Mc) magnetic and electric field fluctuations in the discharge remote from the electrodes. Collapse of the sheath of 10–20 v at peak current and reduction of the frequency of field fluctuations to 0.01–0.1 Mc follow. Fluctuating electric fields also decrease in amplitude by roughly an order of magnitude. (auth)

**32735** (UCRL-Trans-981) THE WAVE EQUATION OF THE ELECTRON IN THE GENERAL RELATIVITY THEORY. L. Infeld and B. L. van der Waerden. Translated by M. S. Little (Univ. of California, Lawrence Radiation Lab., Berkeley) from Sitzber. Deut. Akad. Wiss. Berlin, Kl. Math., Phys. Tech., No. 9, 380-401(1933). 23p.

A simplified development of the Dirac theory of the electron is presented. Only two-rowed matrices are introduced, with the familiar rules of tensor calculus sufficient to govern their formation. The general relativistic generalization of the Dirac equations is obtained, as are the energy momentum tensor and the gravitation equations. (D.C.W.)

**32736** SYMMETRICAL FORM OF DIRAC MATRICES IN GENERAL RELATIVITY. Józef Namysłowski (Jagellonian Univ., Krakow). Acta Phys. Polon., 23: 673-84 (1963). (In English)

A special form of the matrices $\gamma_\mu$ is investigated which is very convenient for arbitrary metric $g_{\mu\nu}$. It is shown that this form is invariant under the group of general coordinate transformations and under a subgroup of spinor transformations that are regarded as independent from coordinate transformations. This form is very useful for proving the equivalence of Vierbein and two-component spinor formalism. The explicit formulas for the elements of $\gamma_\mu$, $\sigma_\mu$, and $\tau_\mu$ are given in terms of the $g_{\mu\nu}$ in a compact form. (auth)

**32737** ON THE CONTINUITY OF THE PETROV CLASSIFICATION. Andrzej Białas (Jagellonian Univ., Krakow). Acta Phys. Polon., 23: 699-703(1963). (In English)

The following theorem is proved: If the Weyl tensor is continuous at a point P, then in some neighborhood of this point the Weyl tensor is not more special (in the sense of Penrose's diagram) than at the point P. (auth)

**32738** USE OF THE PROJECTION IN SOLVING THE VARIATIONAL PROBLEMS. I. N. Michailov (Joint Inst. for Nuclear Research, Dubna, USSR). Acta Phys. Polon., 23: 745-50(1963). (In English)

General relations between solutions of the variational problems $\delta(\Psi, \hat{H}\Psi) = 0$ are discussed. These solutions obey two different subsidiary conditions: (i) $\hat{N}\Psi = N_0\Psi$,

(ii) $(\Psi,\hat{N}\Psi) = N_0$, where the operator $\hat{N}$ is proposed to commute with $\hat{M}$. The role of the operator, which projects $\Psi$ on the space of functions obeying (i), is investigated. It is shown that the usage of the projecting operator is equivalent to finding a solution of the variational problem among a new, extended set of functions. (auth)

**32739** INFRARED SPECTROGRAPHY OF URANIUM AND CALCIUM SILICATES. O. Brieux de Mandirola and E. Silberman. Anales Assoc. Quim. Arg., 49: 293-302 (Dec. 1962). (In Spanish)

Spectrographic analysis were made of uranophane, ranquilite, harweeite, and minerals of Si, Al, Mg, Ca, Co, Sb, Pr, Ti, La, Dy, Mn, Sm, and Lu in the 3-μ wave length range. Spectrum changes of ranquilite and the minerals were noted as a function of heating from 100 to 1000°C. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**32740** ENTROPY PRODUCTION AND HEAT FLOW IN LIQUID He II. Thomas A. Oliphant, Jr. (Los Alamos Scientific Lab., N. Mex.). Ann. Phys. (N. Y.), 23: 38-46 (July 1963). (LADC-5571)

An analysis of the effect of mutual friction between normal fluid and superfluid in the flow of liquid He II through narrow channels under large temperature gradients was recently given by Craig, Keller, and Hammel. This analysis is based on the Gorter-Mellink thermodynamical equations. An alternative treatment of the problem is presented in which the conservation of entropy is introduced naturally into the theory at an early stage. The role played by entropy production in the processes involved in the thermohydrodynamics is thereby considerably clarified and a simple relation is given for an estimate of the relative importance of normal fluid dissipation and mutual friction dissipation. (auth)

**32741** SIMPLE MODEL FOR LONGITUDINAL FORCE-FREE CURRENT FLOW IN SUPERCONDUCTORS OF THE SECOND KIND. C. J. Bergeron, Jr. (Louisiana State Univ., New Orleans and Oak Ridge National Lab., Tenn.). Appl. Phys. Letters, 3: 63-6(Aug. 15, 1963).

A conduction model is proposed which incorporates negative surface-energy terms. A London-type surface-energy contribution is assumed to develop the essential notions of the model, and also the resultant body currents are assumed to flow in a helical, force-free fashion. (R.E.U.)

**32742** CYLINDRICAL AND SPHERICAL SHOCK WAVES IN MONATOMIC CONDUCTING FLUIDS. Roy M. Gundersen (Univ. of Wisconsin, Madison). Appl. Sci. Res., Sect. B, 10: 119-28(1963).

A previously derived first-order differential relation between shock strength and channel area variations, obtained when an initially uniform magnetohydrodynamic shock wave of arbitrary strength propagates with constant speed into an ideal, perfectly conducting, monatomic compressible fluid at rest, is integrated numerically to give a shock strength-area relation valid for channels with continuous area variation. Particular area distributions allow a discussion of converging cylindrical and spherical magnetohydrodynamic shocks. It is shown that near the center, the strengths of such shocks are independent of the applied magnetic field and are given by their gas dynamic values. The usual theory for gas dynamic shock propagation in non-uniform ducts is contained as a special case of the theory presented. (auth)

**32743** NON-RADIAL OSCILLATIONS AND CONVECTIVE INSTABILITY OF GASEOUS MASSES. S. Chandrasekhar and Norman R. Lebovitz (Univ. of Chicago and Massachusetts Inst. of Tech., Cambridge). Astrophys. J., 138: 185-99(July 1, 1963).

Modes of non-radial oscillation of gaseous masses belonging to spherical harmonics of orders $l = 1$ and 3 are considered on the basis of the first and third-order virial equations. For an assumed Lagrangian displacement $\xi$ of the form $\xi_i = (L_{i;jk}\chi_j\chi_k + L_i)e^{i\sigma t}$ (where $L_{i;jk}$ and $L_i$ represent a total of twenty-one unspecified constants and $\sigma$ is the characteristic frequency to be determined), the theory predicts the occurrence of modes of oscillation of two different types: modes (belonging to $l = 3$) that are analogous to the Kelvin modes of an incompressible sphere and modes (belonging to $l = 1$) that are analogous to those discovered by Pekeris for a homogeneous compressible sphere and that exhibit its convective instability. For the latter modes, the virial equations lead to a characteristic equation for $\sigma^2$ of degree 2 whose coefficients are integrals over the variables of the unperturbed configuration, including its superpotential. The theory is applied to the polytropic gas spheres, and it is shown that they are convectively unstable (for the modes belonging to $l = 1$) if the ratio of the specific heats $\gamma$ is less than a certain critical value. The critical values of $\gamma$ predicted by the theory differ from $1 + 1/n$ (where n is the polytropic index) by less than 1 per cent over the range of n ($\leq 3.5$) considered; the extent of this agreement is a measure of the accuracy of the method based on the virial equations and the assumed form of the Lagrangian displacement. (auth)

**32744** THE STRUCTURE OF A SHOCK FRONT IN ATOMIC HYDROGEN. I. THE EFFECTS OF PRECURSOR RADIATION IN THE LYMAN CONTINUUM. Charles A. Whitney and Angelo J. Skalafuris (Harvard Univ., Cambridge, Mass.). Astrophys. J., 138: 200-15(July 1, 1963).

As a step toward understanding the spectra of shock waves in stellar atmospheres, the variations of temperature, density, and electron concentration in a plane steady shock are investigated, and the effects of the Lyman continuum radiation that passes through the shock front into the preshock gas is emphasized. In order to bring out the essential physical problem, a two-stream model for the radiation field is adopted and the simplifying assumptions that the cooling behind the shock takes place by radiative recombinations and that the hot region is optically thin to all continuum radiation and very thick to all significant line radiation are made. Results obtained by neglecting the effects of precursor radiation are presented and an equation giving the photon flux through the shock front in terms of shock velocity and the preshock density and ionization is derived. It is shown that electrons produced in the preshock gas by Lyman continuum radiation cannot recombine before passing through the shock front. A mathematical treatment of the preshock flow is presented, and it is shown that the preshock gas is significantly heated and ionized by precursor radiation, that the region ahead of the shock that is perturbed by Lyman radiation is virtually unobservable except in Lyman radiation, and that the inclusion of precursor radiation significantly raises the gas temperature behind the shock. The calculations agree qualitatively with observations in predicting intense, broad Balmer lines, a weak Balmer continuum, and virtually no emission in other features. (auth)

**32745** THREE "FUNDAMENTAL" RESEARCH PATENTS. P. Bourely. Bull. Inform. Sci. Tech. (Paris), No. 71, 37-43(Apr. 1963). (In French)

One of these patents describes a magnetometer for weak fields, applicable to geophysical prospection. The invention concerns the polarization of protons whose magnetic reso-

nance frequency is measured. It can be analyzed as an extension of the Overhauser effect to the protons of a liquid in interaction with the unpaired electrons of a free radical. The technical aspects of the invention and the legal aspects of its protection are considered. The same is done for two other patents, concerning plasma physics and the future control of thermonuclear fusion. The first describes an annular ion injector. The second describes a plasma gun which needs only a remarkably small magnetic energy input. (auth)

**32746** THE ELECTRON SPIN RESONANCE SPECTRA OF GAMMA-IRRADIATED THIOSULPHATE. R. L. Eager and D. S. Mahadevappa (Univ. of Saskatchewan, Saskatoon). Can. J. Chem., 41: 2106-8(Aug. 1963).

Electron spin resonance spectra were obtained for γ-irradiated hypo- and anhydrous sodium thiosulfate and potassium hypothiosulfate. The spectra for each of the salts appears to be essentially a single absorption line, except for anhydrous $Na_2S_2O_3$, where there is in addition a low-field structure. No hyperfine splitting was observed. The spectra of the samples irradiated for 144 hr at room temperature show an increase in electron spin concentrations with an increase in absorbed dose at first but became almost constant for higher doses. It is believed that $SO_2^-$ free-radical ions are produced in the gamma irradiation of thiosulfates. (P.C.H.)

**32747** RANGE OF $Xe^{133}$ AND $Ar^{41}$ IONS OF kev ENERGIES IN TUNGSTEN. M. McCargo, J. A. Davies, and F. Brown (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Phys., 41: 1231-44(Aug. 1963). (AECL-1779)

An accurate electrochemical technique for the removal of extremely thin (10–1000 Å) uniform layers of metal from a tungsten target has been developed analogous to that used previously for range studies in aluminum. This technique has been used to obtain the range distributions of $Xe^{133}$ and $Ar^{41}$ ions in rolled tungsten foils as a function of energy over the region 2-200 kev approximately. The distributions consist of an asymmetric peak followed by a point of inflection and a very penetrating "tail." Unlike the earlier distributions in aluminum, the "tail" in tungsten is exponential only over a limited region; it eventually decreases in an approximately Gaussian manner. Comparison with theory shows that in tungsten the median range is about a factor of two larger than that predicted by the Lindhard theory. A range distribution has also been obtained for 40-kev $Kr^{85}$ ions in amorphous $WO_3$. This distribution shows no penetrating "tail," a result which is in accordance with recent computer studies by Robinson and Oen (1963), who suggest that the "tails" observed in crystalline (metallic) targets are due to channeling of the incoming ions by the crystal lattice. Also, in $WO_3$, the median range is in reasonable agreement with theory. (auth)

**32748** THE EFFECTS OF PRESSURE ON THE PARAMAGNETIC-ANTIFERROMAGNETIC TRANSITION OF DYSPROSIUM. Peter Landry and Richard Stevenson (McGill Univ., Montreal). Can. J. Phys., 41: 1273-80 (Aug. 1963).

The shift of temperature with pressure of the paramagnetic-antiferromagnetic phase transition of dysprosium at 177°K has been found to be $-(0.55 \pm 0.02) \times 10^{-3}$ deg K/(kg/cm²). Pressure was applied to the substance by compressing the metal between two pistons in a cylinder. The transition point was determined by measuring the magnetic moment of the sample as a function of temperature at various pressures up to 8400 kg/cm². The results appear to be consistent with current theories of the magnetic properties of dysprosium. (auth)

**32749** CALCULATION OF THE SURFACE ENERGY OF THE {110} FACE OF SOME CRYSTALS POSSESSING THE FLUORITE STRUCTURE. G. C. Benson and T. A. Claxton (National Research Council, Ottawa). Can. J. Phys., 41: 1287-93(Aug. 1963). (NRC-7453)

A method of calculating the surface energy of an ionic crystal is outlined and illustrated by application to the {110} face of crystals having the fluorite structure. Numerical results are given for $CaF_2$, $SrF_2$, and $BaF_2$, and are compared with values calculated previously for the {111} face of these crystals. (auth)

**32750** ZEEMAN EFFECT ANALYSIS OF THE NEUTRAL SPECTRUM OF LUTETIUM. E. H. Pinnington (Imperial Coll. of Science and Tech., London). Can. J. Phys., 41: 1294-1304(Aug. 1963).

Results are presented for the Zeeman effect obtained in a field of 27,000 gauss for 40 lines due to Lu I. These lines were excited in an electrodeless discharge in lutetium iodide activated by 2450-Mc/s microwave radiation. The assignment of spectroscopic terms to energy levels in Lu I is discussed, the Zeeman effect data being used to identify six new terms and to confirm nine others, and a summary is presented of all similar pertinent data. The presence of a relatively large hyperfine structure in some of the Lu lines investigated has been found to cause marked deviations in the resultant Zeeman patterns from that to be expected on the basis of L-S coupling. These deviations are discussed and compared with what may be expected when appreciable A and B h.f.s. splitting factors are involved. (auth)

**32751** ZEEMAN EFFECT DATA FOR SINGLY IONIZED LUTETIUM. E. H. Pinnington (Imperial Coll. of Science and Tech., London). Can. J. Phys., 41: 1305-6 (Aug. 1963).

Zeeman patterns are listed for the Lu II lines at 2969.8, 3198.1, 3254.3, 4184.2, 5476.7, and 6611.7 Å. These results are used to determine the g factors for the levels at 11796, 14199, 17332, 32453, 41225, 44919, and 45458 $cm^{-1}$. (auth)

**32752** GROWTH OF MUTUAL FRICTION IN LIQUID HELIUM II. S. M. Bhagat (Univ. of Maryland, College Park) and P. R. Critchlow. Can. J. Phys., 41: 1307-13 (Aug. 1963).

An explanation is offered to account for the fact that two propagation velocities of turbulence, one in either direction, may be observed when a heat current is applied to a long, narrow channel containing liquid helium II. The theory also gives qualitatively the correct dependence of the velocities on temperature and heat current. (auth)

**32753** THE EFFECT OF PRESSURE ON THE ELECTRICAL RESISTANCE OF LITHIUM. D. Gugan (Bristol Univ., Eng.). Can. J. Phys., 41: 1381-4(Aug. 1963).

The change of resistance of lithium with hydrostatic pressure has been studied at low temperatures. Anomalous results have been found at all temperatures. The pressure coefficient of residual resistivity of dilute alloys of magnesium in lithium has been found to depend on the structure of the parent lattice. (auth)

**32754** OBSERVATION OF SPIN INDUCTION IN THE ELECTRON PARAMAGNETIC RESONANCE. N. V. Kravtsov, V. N. Lazukin, and N. V. Chekalin (Moscow State Univ.). Dokl. Akad. Nauk SSSR, 150: 1267-9(June 21, 1963). (In Russian)

One of the methods used for the determination of the nuclear magnetic resonance involves the measurement of the emf generated in the auxiliary coil by the precession of nuclear spins in a constant field $H_0$ and of the simultaneous interaction by the radiofrequency field $H_y$, acting perpendicularly on $H_0$. A similar situation exists also in the case of electron spins exposed to $H_0$ and $H_y$. An attempt was made to measure the electron paramagnetic resonance by recording the spin induction, making use of a 9500-megaherz, klystron-generated frequency. Oscillographic studies with diphenyl picryl hydrazyl and yttrium ferrite single crystals were used for verifying the results. The spin-induction method may also be used for electron paramagnetic resonance studies by radiospectroscopic means with superheterodyne detectors; the method may be used also for determining the relaxation time on the basis of pulse measurements. (TTT)

**32755** ONE-DIMENSIONAL UNSTABLE CONDUCTING GAS FLOW IN STRONG ELECTROMAGNETIC FIELDS. G. M. Bam-Zelikovich. Izv. Akad. Nauk SSSR, Otd. Tekhn. Nauk, Mekhan. i Mashinostr., No. 2, 3-10(1963). (In Russian)

Equations were derived for the one-dimensional unstable flow of compressed conducting gas acted upon by strong magnetic fields. The equations are resolved by a series of small parameters. Moreover, the consequent series terms are reduced to squares. Concrete examples demonstrating the difference between the described motion and quasistationary motion are given. (tr-auth)

**32756** ELECTRON PARAMAGNETIC RESONANCE ABSORPTION STUDIES OF NEUTRON-IRRADIATED $\alpha,\alpha$-DIPHENYL-$\beta$-PICRYL HYDRAZINE. Y. W. Kim and P. W. France (Wayne State Univ., Detroit). J. Chem. Phys., 38: 1453-4(Mar. 15, 1963). (TID-17990)

The possibility of forming molecules of $\alpha,\alpha$-diphenyl-$\beta$-picryl hydrazyl (DPPH) in $\alpha,\alpha$-diphenyl-$\beta$-picryl hydrazine ($DPPH_2$) by irradiating the latter is discussed. The EPR absorption spectrum of dilute liquid solutions of irradiated $DPPH_2$ exhibited a very close similarity with the EPR absorption in dilute liquid solutions of DPPH. The two spectra are centered at $g = 2.0036 \pm 0.0006$ and consist of five resolved hyperfine lines, equally spaced 10 G apart, with intensities varying approximately in the ratio of 1:2:3:2:1. Thus the two spectra are identical with respect to hyperfine structure and g value. (P.C.H.)

**32757** WHISTLERS EXCITED BY NUCLEAR EXPLOSIONS. R. A. Helliwell and D. L. Carpenter (Stanford Univ., Calif.). J. Geophys. Res., 68: 4409-20(Aug. 1, 1963).

The dynamic spectra of whistlers excited by five nuclear explosions are found to be identical to those of natural whistlers observed within a few minutes of shot time. Two shots fired at the Nevada proving ground produce normal two-hop whistlers at Stanford, 600 km to the west. Three shots fired over Johnston Island (about 14°N geomagnetic latitude) produce one-hop whistlers, some of which are received at northern hemisphere stations as far away as Stanford, 5100 km to the northeast. No whistlers are observed on Kauai, only 1200 km northeast of Johnston Island. Analysis shows that the magnetospheric paths of natural and explosion-excited whistlers are essentially the same, and that these paths are fixed in the ionosphere and are not necessarily close to the impulse source or the receiver. From analysis of impulse-whistler delays of shot Teak, it is deduced that the one-hop whistler received at Stanford is excited by an impulse that first crosses the equator in the earth-ionosphere wave guide before entering the whistler duct in the southern hemisphere, as suggested in the concept of the hybrid whistler. The high-altitude shot Starfish Prime (July 9, 1962) is detonated at 400-km altitude, but the dispersion of the source impulse is similar to that of ordinary lightning impulses. This result is interpreted to mean that the impulse is produced below the ionosphere, thus providing support for the Compton-electron mechanism of impulse generation. The similarity between the natural and shot-excited whistlers leads to the conclusion that shot-excited whistlers cannot be used for the purpose of detecting nuclear explosions. (auth)

**32758** MORATORIUM TRITIUM GEOPHYSICS. W. F. Libby (Univ. of California, Los Angeles). J. Geophys. Res., 68: 4485-94(Aug. 1, 1963).

The additions of artificial tritium to the atmosphere by the explosion of thermonuclear devices before the beginning of the three-year moratorium on nuclear testing in August 1958 are observed, as they distributed themselves among the surface waters and in the atmosphere, by measurement of the tritium content of water samples taken during the moratorium. These data help fill in a geophysical picture for the movements of the surface waters and atmospheric moisture and give the following conclusions: the bomb and natural tritium distributions are roughly proportional, and so the same factors control their distribution, and at the end of the moratorium there is about twelve times as much tritium in the waters of the northern hemisphere as the natural inventory; the total bomb tritium released offsite before 1961 is about $2 \cdot 10^{28}$ atoms as of the summer of 1961, of which about $1.5 \cdot 10^{27}$ are still in the stratosphere; the tritium stratospheric fallout shows a peak at middle latitudes similar to that found for stratospheric particulate matter such as $Sr^{90}$; summer maximums appear in the tropospheric moisture over continents and downwind therefrom because of evaporation of top surface water of high concentration, possibly by means of plant transpiration; the principal mechanism for movement of water over the world is the wind; and a reconsideration of the data on natural tritium indicates that the mean precipitation rate of the Pacific and Atlantic in the 30 to 50°N latitude band is about 2.5 meters/year as contrasted with the U. S. land figure of 0.68 meter/year. The discrepancy may be caused by 1.7 meters/year of ocean spray that equilibrates with atmospheric moisture. (auth)

**32759** ARTIFICIAL BERYLLIUM 7 IN THE LOWER STRATOSPHERE. J. F. Bleichrodt and E. R. van Abkoude (TNO, Rijswijk, Netherlands). J. Geophys. Res., 68: 4629-31(Aug. 1, 1963).

It is found that the concentrations of $Be^7$ and $Sr^{89}$ above the tropopause follow the relation $[Be^7] = C + x[Sr^{89}] \exp(0.00078t)$. The measured value of x is 0.038, and the exponential is introduced as a result of the different half lives of the isotopes under study. C is the cosmic-ray-produced natural concentration of $Be^7$, and t is the estimated time after a thermonuclear explosion. The reason for this relation is assumed to be that the $Be^7$ is produced by the detonation of thermonuclear devices containing Li, and the $Sr^{89}$ is produced in the fission devices used as a trigger for the thermonuclear devices. (T.F.H.)

**32760** THE NATURE OF THE AXIOMS OF RELATIVISTIC QUANTUM FIELD THEORY. [PART] II. E. C. G. Sudarshan (Univ. of Rochester, N. Y.). J. Math. Phys. (N. Y.), 4: 1029-36(Aug. 1963). (NYO-10258)

The study of the nature and interdependence of the axioms of relativistic field theory is continued; attention is focused on the notion of relativistic invariance. The

central result is the derivation of necessary and sufficient conditions for a representation of the covariant free field to admit a unitary representation of the inhomogeneous Lorentz group associated with the field operator. It is shown that only the standard Fock–Cook representation has this property. The relevance of the requirement that the Lorentz group is represented by a unitary family associated with the field operator is exhibited by an analysis of the covariant representations of Shale and Segal. These representations involve extremal states that are not pure, and group representations by intertwinning operators. (auth)

**32761** GENERALIZED "CROSS-CORRELATION" FIELD QUANTITIES AS SOLUTIONS OF FIELD EQUATIONS. Philip R. Karr (Space Tech. Labs., Inc., Redondo Beach, Calif.). J. Math. Phys. (N. Y.), 4: 1037-9(Aug. 1963).

It was shown by Wolf that, if a field amplitude obeys the wave equation, then a derived field quantity (the cross correlation or mutual coherence function), also obeys the wave equation. This result helps clarify the subject of partially coherent light; for example, a Huygens' principle for the propagation of intensity is a consequence. A generalization is presented: for that class of linear partial differential equations (p.d.e.'s) in which at least one independent variable, say t, does not appear in the coefficients, one can construct from a solution f(P,t), (P representing collectively the other independent variables) a generalized cross-correlation function F(P,t; $P_1$, $t_1$, $P_2$, $t_2$...) satisfying the same p.d.e. as f(P,t); F is an integral over s of f(P,t + s)g (s, $P_1$, $t_1$, $P_2$, $t_2$...), where ($P_1$, $t_1$, $P_2$, $t_2$...) are values of (P, t); for particular choices of the highly arbitrary g, F can be, for example, the usual cross-correlation function, used by Wolf, a higher-order correlation function, the Hilbert transform of f(P,t), and derivatives of f(P,t). For linear p.d.e.'s in which two or more independent variables have the above property, higher-dimensional or vector versions of F are obtainable. The existence of this (two-fold) generalization of Wolf's result suggests the possibility of other physical applications. (auth)

**32762** CONTINUOUS-REPRESENTATION THEORY. I. POSTULATES OF CONTINUOUS-REPRESENTATION THEORY. John R. Klauder (Bell Telephone Labs., Murray Hill, N. J.). J. Math. Phys. (N. Y.), 4: 1055-8(Aug. 1963).

In a continuous representation of Hilbert space, each vector $\Psi$ is represented by a complex, continuous, bounded function $\phi(\Phi) \equiv (\Phi,\Psi)$ defined on a set S of continuously many, nonindependent unit vectors $\Phi$ having rather special properties: each vector in S possesses an arbitrarily close neighboring vector, and the identity operator is expressible as an integral over projections onto individual vectors in S. In particular cases it is convenient to introduce labels for the vectors in S whereupon each $\Psi$ is represented by a complex, continuous, bounded, label-space function. Basic properties common to all continuous representations are presented, and some applications of the general formalism are indicated. (auth)

**32763** CONTINUOUS-REPRESENTATION THEORY. II. GENERALIZED RELATION BETWEEN QUANTUM AND CLASSICAL DYNAMICS. John R. Klauder (Bell Telephone Labs., Murray Hill, N. J.). J. Math. Phys. (N. Y.), 4: 1058-73(Aug. 1963).

An application to the study of dynamics of the typical overcomplete, nonindependent sets of unit vectors that characterize continuous-representation theory is discussed. It is shown in particular that the conventional, classical hamiltonian dynamical formalism arises from an analysis of quantum dynamics restricted to an overcomplete, nonindependent set of vectors that lie in one-to-one correspondence with, and are labeled by, points in phase space. A generalized classical mechanics is then defined by the extremal of the quantum-mechanical action functional with respect to a restricted set of unit vectors whose c-number labels become the dynamical variables. This kind of classical formalism is discussed in some generality, and is applied not only to simple single-particle problems, but also to finite-spin degrees of freedom and to fermion field oscillators. These latter cases are examples of an important class of problems called exact, for which a study of the classical dynamics alone is sufficient to infer the correct quantum dynamics. (auth)

**32764** STUDY OF SEVERAL LATTICE SYSTEMS WITH LONG-RANGE FORCES. M. Kac (Rockefeller Inst., New York) and E. Helfand. J. Math. Phys. (N. Y.), 4: 1078-88(Aug. 1963).

A number of one and two-dimensional Ising lattice systems with long-range ferromagnetic interactions are studied. The theory introduces as basic variables stochastic fields acting at each site, but goes beyond Weiss mean-field theory in giving a complete account of the statistics of these fields. A transition is manifest in these systems by a shift in the values of the stochastic fields that are important for the calculation of the partition function. Particulate attention is devoted to the critical region where the range of significant stochastic fields broadens. The equation of state for the lattice gas corresponding to this model is of the van der Waals type. Comparison is frequently made between these results and the properties of an analogous one-dimensional continuum system studied by Kac, Uhlenbeck, and Hemmer. (auth)

**32765** A THEORY OF THE LINE INTENSITIES IN TWO-QUANTUM TRANSITIONS. Yves Ayant (Faculté des Sciences, Grenoble, France). J. Phys., 24: 225-32(Apr. 1963). (In French)

A theory is presented of the form and intensity of the lines of two-quanta transitions. The theory is valid in such cases as deuterons in heavy or semi-heavy water, contained in zeolites. (auth)

**32766** STUDY OF THE SOLUTIONS OF THE STATIONARY BOLTZMANN EQUATION. J. Tavernier (Laboratoire Central des Industries Electriques, Fontenay-aux-Roses, France). J. Phys., 24: 241-4(Apr. 1963). (In French)

From a physical interpretation, a method of solving Boltzmann's equation for stationary states is developed. The solution, within the relaxation-time approximation, is valid for all magnitudes of the electric fields, thermal gradients, and magnetic fields. (auth)

**32767** WAVE FUNCTIONS FOR THE HYDROGEN MOLECULE AND MOLECULE ION. H. C. Bowen and J. W. Linnett (Inorganic Chemistry Lab., Oxford). Mol. Phys., 6: 387-92(May 1963).

Calculations have been carried out using wave functions for $H_2^+$ and $H_2$ in which polarization of the atomic 1s orbitals is achieved by combining them with off-center 1s-type orbitals. It is found that for both species the use of this method is not worthwhile compared with the employment of 2p-type orbitals. This agrees with the conclusions of Geller et al., for $H_2^+$. The magnitudes of the constants for a wide range of internuclear distances are tabulated and discussed. (auth)

**32768** COMPARATIVE MEASUREMENTS OF YIELDS OF D-D NEUTRONS FROM DIFFERENT TARGETS. M. Paić, B. Antolković, P. Tomaš, and M. Turk (Institut "Rudjer Boskovic," Zagreb). Nucl. Instr. Methods, 23: 19-23(May 1963). (In English)

The study of the conditions on a neutron generator of 200 kev was undertaken to obtain the maximal neutron flux. As targets, heavy ice, copper bombarded with deuterons, and a Ti-D foil were used. A steady maximal total flux with the heavy ice target was $2.9 \times 10^8$ $sec^{-1}$ ($7.3 \times 10^5$ $sec^{-1}$ $\mu a^{-1}$) while the values obtained with the self-formed D target on copper foil and with the Ti-D target were $2.7 \times 10^7$ $sec^{-1}$ ($1.7 \times 10^5$ $sec^{-1}$ $\mu a^{-1}$) and $1.5 \times 10^8$ $sec^{-1}$ ($3.3 \times 10^6$ $sec^{-1}$ $\mu a^{-1}$) respectively. The neutron yield is given as a function of the parameters: energy and current of incident deuterons, time of condensation of heavy ice before bombardment, time of bombardment, and the flow of heavy water vapors. (auth)

**32769** ON THE PREPARATION OF THIN CONVERTER FOILS AND RADIOACTIVITY SOURCES BY CATHODE SPUTTERING. A. F. Meyer (Deutsche Akademie der Wissenschaften, Berlin, Forschungsstelle für Physik Hoher Energien, Zeuthen, Ger.). Nucl. Instr. Methods, 23: 77-8 (May 1963). (In German)

A simple apparature for sputtering of cathodes is described and the obtained experimental results are presented. (auth)

**32770** PREPARATION OF THIN BETA-RAY SOURCES AND URANIUM CONVERTORS BY CATHODE SPUTTERING. M. Mladenović and Ali-El-Farash (Atomic Energy Establishment, Cairo). Nucl. Instr. Methods, 23: 175-7 (May 1963). (In English)

Results are reported of work on the cathode sputtering technique for preparation of radioactive sources. A sputtering chamber is described. Sputtering rates of a number of metals are tabulated. The use of cathode sputtering for preparing uranium convertor foils was investigated and found to be feasible. (D.L.C.)

**32771** APPLICATION OF CHARGED AND NEUTRAL BEAMS IN MEASUREMENTS OF GYROMAGNETIC RATIOS. G. Goldring, Drora Kedem, U. Smilansky, and Z. Vager (Weizmann Inst. of Science, Rehovoth, Israel). Nucl. Instr. Methods, 23: 231-4(June 1963). (In English)

Measurements of the cross sections for the reactions $H_2^+ \rightarrow H + H^+$, $H_2^+ \rightarrow 2H^+ + e^-$, and $H \rightarrow H^+ + e^-$, occurring when a 3-Mev $H_2^+$ beam passes in a hydrogen or nitrogen atmosphere, are carried out, as well as the cross section for the reaction $He^+ \rightarrow He^{++} + e^-$ for a 3-Mev $\alpha$ beam in a nitrogen atmosphere. These reactions are important in measurements of gyromagnetic ratios employing excitation with charged and neutral beams. (auth)

**32772** A METHOD FOR MEASURING THE ENERGY OF ALPHA-PARTICLE BEAMS IN THE REGION 5 TO 30 Mev. J. Benveniste, A. Mitchell, and R. Thomas (Univ. of California, Livermore). Nucl. Instr. Methods, 23: 349-52(June 1963). (UCRL-7104) (In English)

A method for measuring the energy of alpha-particle beams is described. The alpha particles are passed through aluminum absorbers until their residual energy is comparable with that of known alpha-particles from a radioactive source. It is shown that the method permits an energy measurement with the precision of the knowledge of the range-energy relation for alpha-particles in aluminum. (auth)

**32773** QUANTUM CORRECTIONS TO THE SECOND VIRIAL COEFFICIENT FOR HELIUM AT HIGH TEMPERATURES. Franz Mohling (Univ. of Colorado, Boulder). Phys. Fluids, 6: 1097-1103(Aug. 1963).

The high-temperature quantum corrections to the second virial coefficient are calculated for a square-well repulsive core model. It is shown that the hard core correction is large for $He^4$ at all temperatures for which present measurements exist. The correction can be verified experimentally, because it leads to a 5% difference between $He^4$ and $He^3$ values at high temperatures. (auth)

**32774** STABILITY OF HYDROMAGNETIC KELVIN-HELMHOLTZ DISCONTINUITY. Amiya K. Sen (Columbia Univ., New York). Phys. Fluids, 6: 1154-63(Aug. 1963).

The most general form of hydromagnetic Kelvin–Helmholtz discontinuity in ideal incompressible fluids was considered. The presence of surface tension on the surface of discontinuity and gravity is also assumed. The stability of the hydromagnetic flow of two uniform infinite streams with planar interface exhibiting this type of discontinuity, was analyzed in detail. Two necessary and sufficient criteria for its stability were obtained, in contrast to only one that is usually given. The stabilizing effect of magnetic field is strongly dependent on its discontinuity at the interface and its orientation relative to that of streaming. The consideration of the stability to a single mode of perturbation leads to the conclusion that this is dependent on the above mentioned factors, as well as the following ones. The effect of surface tension and gravity is dependent on the wavelength, while that of the magnetic field is dependent on the direction of propagation of perturbation. (auth)

**32775** SKIN EFFECT IN MAGNETO-FLUID DYNAMIC TRAVELING WAVE DEVICES. Joseph L. Neuringer and Eugene Migotsky (Avco Mfg. Co., Wilmington, Mass.). Phys. Fluids, 6: 1164-8(Aug. 1963).

Electromagnetic propagation through an infinite circular cylindrical traveling wave tube in which a conducting fluid of constant conductivity is moving axially with uniform speed is studied. Asymptotic solutions valid for $|\alpha R_0| \ll 1$ and $|\alpha R_0| \gg 1$, where $\alpha$ is the complex separation constant and $R_0$ the tube radius, are obtained and analyzed. Concentrating specifically on the axial body force per unit tube length induced on the fluid, the $|\alpha R_0| \gg |$ solution indicates, fixing the current sheet input and geometry, that the magnitude of the induced axial force is a marked function of the dimensionless parameter $\beta$, equal to the magnetic Reynolds number based on wavespeed and wavelength multiplied by the slip. The body force rises linearly with $\beta$ for small $\beta$, reaches a peak and then, because of the inability of the electromagnetic field to penetrate into the conductor with increasing $\beta$ (skin effect), falls like $\beta^{-1/2}$ for large $\beta$. From the practical viewpoint, the results suggest the adjustment of the electrical and fluid mechanical parameters so that operation occurs at that value of $\beta$ that optimizes the force. It is further indicated, especially for moderate to high $\beta$ operation, that for efficient utilization and conservation of working fluid mass and electrical energy, injection and acceleration take place in an annulus close to the coils rather than throughout the entire cross section. (auth)

**32776** PHENOMENA ALONG THE hcp-bcc TRANSITION LINE OF $He^3$ AND $He^4$. A. F. Schuch, W. C. Overton, Jr., and R. Brout (Los Alamos Scientific Lab., N. Mex.). Phys. Rev. Letters, 10: 429-31(May 15, 1963). (LADC-5668)

An empirical study of the phenomena along the hcp-bcc transition line of $He^3$ and $He^4$ is based on recently available experimental data. A tentative interpretation of the phase

transition is given. It is suggested that the solid phase transition occurs at the point of inflection of the potential energy versus R (nearest-neighbor distance) curve. In going from the hcp to the bcc phase the crystal undergoes a transition to a more open structure in order to give the zero-point motion more play. (A.G.W.)

**32777** ON X-RAY NON-DIAGRAM LINES. C. L. Roy and S. T. H. Abidi (Indian Inst. of Tech., Kharagpur, India). Physica, 29: 631-2(June 1963). (In English)

In characteristic x-ray-emission spectra there are frequencies usually known as satellites or nondiagram lines that do not fit in the singly ionized energy level scheme of atoms emitting the so-called diagram lines like $K_\alpha$, $K_\beta$, $L_\alpha$, etc. It is shown that there are a few relationships that are obeyed identically both by satellites and diagram lines. (L.T.W.)

**32778** ON THE HYPER-CHAIN EQUATION OF STATE OF A HARD-SPHERE GAS. P. Hutchinson and G. S. Rushbrooke (King's Coll., Newcastle-upon-Tyne, Eng.). Physica, 29: 675-80(June 1963). (In English)

Estimates are made of the sixth virial coefficient, F, for a hard-sphere gas on the basis of the hyper-chain approximation in the theory of classical fluids, and also on other approximations which take some account of the first elementary diagram. Hyper-chain isothermals, curtailed at the term in F, are compared with Kirkwood and Born-Green curves, and with the results of Monte Carlo calculations. It is suggested that F is probably of magnitude approximately 0.04. (auth)

**32779** THE DYNAMIC POLARIZATION OF PROTONS IN POLYSTYRENE. T. J. B. Swanenburg, N. J. Poulis, and G. W. J. Drewes (Kamerlingh Onnes Laboratorium, Leiden, Netherlands). Physica, 29: 713-20(June 1963). (In English)

The dynamic polarization of protons in polystyrene was measured in the temperature region from 1.3 to 20.0°K at various concentrations of DPPH spins dissolved in the polystyrene. In the same temperature region the spin-lattice relaxation times of the protons and of the electron spins were measured, in the samples containing 1% and 5% DPPH by weight. The observed enhancements are in agreement with those calculated from the relaxation times. (auth)

**32780** A DIRECT MEASUREMENT OF THE MINIMUM IN THE MELTING CURVE OF $^4$He. C. Le Pair, K. W. Taconis, R. De Bruyn Ouboter, and P. Das (Kamerlingh Onnes Laboratorium, Leiden). Physica, 29: 755-6(June 1963). (In English)

A direct technique was applied to measure the difference between the lowest melting pressure and the melting pressure at temperatures below the one at which the minimum occurs. (L.T.W.)

**32781** CALCULATIONS OF A BOUNDARY ON DIELECTRIC PLANE STREAMLINED BY AN INCOMPRESSIBLE ANISOTROPICALLY CONDUCTING FLUID IN PRESENCE OF UNIFORM, NORMAL TO THE PLANE, MAGNETIC FIELD. V. B. Baranov, G. A. Lyubimov, and Hu Yu Ying. Prikl. Mat. i Mekhan., 27: 509-22(May-June 1963). (In Russian)

The problem of boundary flow of incompressible anisotropic-conducting fluid over a plane was studied for cases of weakly ionized and completely ionized fluids under various external magnetic flux conditions. It was assumed that the cyclotron ion rotation frequency is small in comparison to collision frequencies. The solution was resolved with a computer using a given parameter. (R.V.J.)

**32782** OSCILLATION PERTURBATIONS IN CONDUCTING FLUID IN MAGNETIC FIELD. M. I. Shliomis. Prikl. Mat. i Mekhan., 27: 523-31(May-June 1963). (In Russian)

Effects of uniform magnetic field on the attenuation of small equilibrium perturbations in a conducting fluid in a channel of arbitrary shape were studied. It is shown that with a small Hartman number there are two types of normal perturbations (magnetic and hydrodynamic) that are dampened with monotonous persistence. (R.V.J.)

**32783** THE MOTION OF A NON-CONDUCTING SPHERE THROUGH A CONDUCTING FLUID IN A MAGNETIC CROSS-FIELD. G. S. S. Ludford and M. P. Singh (Cornell Univ., Ithaca, N. Y.). Proc. Cambridge Phil. Soc., 59: 615-24(July 1963).

The problem for a perfectly conducting sphere was considered by Stewartson. Here a different method and a more realistic assumption concerning the sphere are used. Although the flow is still ultimately cylindrical, there is no longer a column of fluid that moves with the sphere as if solid. There is no reason to expect that in practice the flow will break away into eddies. In fact the same is true in Stewartson's case, once his results are corrected. (auth)

**32784** ON THE MOTION OF A SPHERE THROUGH A CONDUCTING FLUID IN THE PRESENCE OF A MAGNETIC FIELD. G. S. S. Ludford and M. P. Singh (Cornell Univ., Ithaca, N. Y.). Proc. Cambridge Phil. Soc., 59: 625-35(July 1963).

Errors in a previous discussion of the problem for a perfectly conducting sphere are corrected. An alternative method of determining the ultimate motion is described for both a perfectly conducting and a non-conducting sphere moving along the magnetic field. (auth)

**32785** ELECTRON AND PHONON SCATTERING. II. THERMOELECTRICITY IN RUBIDIUM, CAESIUM AND ALLOYS AT VERY LOW TEMPERATURES. A. M. Guénault and D. K. C. MacDonald (National Research Council, Ottawa). Proc. Roy. Soc. (London), Ser. A, 274: 154-62(July 23, 1963).

Following earlier measurements on pure potassium and alloys, a corresponding study at very low temperatures of thermoelectricity in rubidium, cesium, and their alloys with each other and with potassium was made. The results proved in accord with the interpretation of the earlier work, and the trends observed in both the electron diffusion and phonon-drag contributions to the absolute thermoelectric power are discussed. Both contributions as observed in these metals are consistent with a larger distortion in the Fermi surface of cesium than in those of potassium or rubidium. It appears that the changes in the thermoelectric diffusion term can be attributed consistently to the difference arising from large-angle and small-angle scattering. It is supposed that in turn these types of electron scattering arise from the presence of homovalent and heterovalent impurity centers. (auth)

**32786** CLOUD CHAMBER STUDY OF ELECTRON AVALANCHE GROWTH. K. R. Allen and K. Phillips (Associated Electrical Industries Research Lab., Manchester, Eng.). Proc. Roy. Soc. (London), Ser. A, 274: 163-86 (July 23, 1963).

The growth of avalanches and the transition to a visible discharge was studied in air, nitrogen, argon, carbon dioxide, hydrogen, and oxygen by means of an expansion cloud chamber. The effect of expansion ratio, vapor filling, and type of gas on the formation of droplets was investigated. Pulse lengths of 0.11, 0.08 and 0.05 μs and pres-

sures of 400, 580, and 680 mmHg were used in air and agreement with previous mobility measurements found. As the voltage was increased the shape of the avalanche changed, its breadth increased and finally a filamentary visible discharge was produced. The position of the avalanche head at the time of transition was correlated with the occurrence of a constriction in the visible discharge at the same point. A single avalanche was found to be sufficient to form a streamer. Streamer thresholds were measured as a function of pulse length, and vapor filling. The addition of methyl, ethyl, or propyl alcohol to dry nitrogen reduced the streamer threshold by about 14%. Reduction of pulse length increased the streamer threshold. Nitrogen was very similar to air in regard to the effect of pulse length, vapor filling and voltage. The streamer constriction could be moved nearer the cathode with increasing voltage and its position ($x_{cr}$ being distance from cathode) was given by $\alpha x_{cr} = 14$ to 20 depending on pressure and pulse length. The X/p value of streamer threshold was unaffected by a change of pd from 150 to 780 mmHg cm. Streamers were produced in argon but overvoltages of up to 200% were required. Effect of vapor and pulse length was similar to air. Carbon dioxide was difficult to use owing to its dissociation by ultra-violet light, and agreement with mobility measurements in the dry gas is not very good. Streamers were obtained with overvoltages. Results for hydrogen were in reasonable agreement with previous mobility measurements. Velocity measurements in oxygen were less than the previous values, but this is most likely caused by electron attachment that reduced the apparent length of the avalanche. Streamers with bright knobs at the constriction were observed. The position of the avalanche head was calculated based on the assumption that it coincided with the neck in the streamer, and agreement with observation particularly at high X/p values was found. Thermal energy derived from avalanche width and velocity differs by as much as a factor of 2 and a possible explanation is put forward. (auth)

**32787** SPACES CONFORMAL TO A CLASS OF SPACES IN GENERAL RELATIVITY. P. Szekeres (King's Coll., London). Proc. Roy. Soc. (London), Ser. A, 274: 206-12 (July 23, 1963).

A study of conformal transformations of a Riemannian $V_4$ is made with the framework of the Penrose spinor formalism. In particular the conformal properties of a whole hierarchy of spaces occurring in general relativity are considered, and necessary and sufficient conditions are established for a space to be conformal to a space in which the conform tensor is divergence-free, to an empty space, and to an Einstein space. The case of Petrov type N is treated separately. (auth)

**32788** RESONANT ELECTRON SCATTERING BY ATOMS. A. Herzenberg and F. Mandl (Univ. of Manchester, Eng.). Proc. Roy. Soc. (London), Ser. A, 274: 253-66(July 23, 1963).

The Kapur–Peierls resonance formalism adapted for electron scattering by atomic systems is modified to allow for the exclusion principle, and a variational principle is derived for calculating the complex resonance energies. The theory is applied to calculate the first four resonance levels in the $^1S$ state of the electron/atomic hydrogen system by using a trial wave function made up from single-particle functions that are modified (1s), (2s), and (2p) hydrogen wave functions. Two levels (at approximately –13 and –10 ev) whose widths are of the order of a few volts are found. There are also two levels (at about –3 and 0 ev) that have very narrow widths, less than $10^{-2}$ ev, if they occur below the inelastic threshold, shooting up to widths of several volts at threshold. Such a narrow level occurs if the resonant state is energetically unable to decay to a state of the residual atom of which it contains a substantial component. (auth)

**32789** K X-RAY YIELDS FROM ELEMENTS OF LOW ATOMIC NUMBER. A. J. Campbell (Associated Electrical Industries Ltd., Aldermaston, Berks; Eng.). Proc. Roy. Soc. (London), Ser. A, 274: 319-42(July 30, 1963).

Absolute measurements were made of the K x-ray quantum yields resulting from electron bombardment of solid targets containing the Be, B, C, O, F, and Al. BeO and LiF targets were used for the O and F measurements, respectively; targets containing at least 99% of the pure element were used for the remainder. The gas-flow proportional counter was operated at atmospheric pressure with a nitro-cellulose window; the window used for detecting beryllium and boron radiation was less than 1000 Å thick. The relation variation of the x-ray yield with the electron accelerating voltage is in excellent agreement with Archard's predictions for the yield measured both at 45° and 10° to the target surface but with the electron beam normal to the surface. The absolute yield values, apart from those for beryllium, are 5 to 15% higher than those calculated from Archard's theory and Burhop's fluorescence yield formula; the beryllium yield is about half that predicted. For $5 \leq Z \leq 9$, the greatest x-ray yield at 45° of the target surface is obtained when the accelerating kilovoltage is between $0.5\,(Z-1)^2$ and $0.6\,(Z-1)^2$ and amounts to $9 \times 10^{13}\ Z^{4}$ photons per incident coulomb per steradian ($1.45 \times 10^{-5}$ Z photons per incident electron per steradian). (auth)

**32790** IONIZATION BY PROTONS IN THE ENERGY RANGE 100 TO 450 kev. H. B. Gilbody and A. R. Lee (University Coll., London). Proc. Roy. Soc. (London), Ser. A, 274: 365-70(July 30, 1963).

Ionization at 100 to 450 kev was investigated by the well-known parallel-plate condenser method. A uniform axial magnetic field enables slow ion collection to be carried out over a precisely determined path length at pressures low enough to ensure single collision conditions. The total cross-section for slow ion production $\sigma_+$, and the total ionization cross-section $\sigma_e$ were determined for protons in hydrogen, helium, neon, argon, and krypton. It is found that charge transfer is very small above about 200 kev so that $\sigma_+ \simeq \sigma_e$. The ionization cross-section for all cases falls off as $E^{-1}$ log E where E is the energy of the relative ionization cross-sections for the same relative velocity of impact. The results are therefore in agreement with the general predictions of the Born approximation. (auth)

**32791** IDEAL POLAR SURFACES NECESSARY FOR WEAK- OR STRONG-FOCUSING NUCLEAR INSTRUMENTS. C. C. Iliescu (Inst. of Atomic Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 127-41(1963). (In French)

A generalized function is found for the shapes of idealized pole faces for weak- and strong-focusing nuclear apparatus. The function can be simplified as the allowable error increases. (T.F.H.)

**32792** RESPONSE OF SEMICONDUCTOR DETECTORS TO FISSION FRAGMENTS. Herbert Flicker (Radio Corp. of America, Princeton, N. J.). Rev. Sci. Instr., 34: 822 (July 1963).

Britt and Wegner (ibid., 34: 274) observed that pulse heights from $Cf^{252}$ fission fragments in semiconductor detectors correspond to a consistent error of at least 4 to 6 Mev. It is suggested that a fission fragment may dissi-

pate several Mev of energy in nonionizing atomic collisions in silicon. From theoretical considerations, it is deduced that at least 3 Mev of the energy loss of fission fragment would be lost in atomic collisions. (D.L.C.)

**32793** STABILITY OF THE MOVEMENT OF A CHARGED PARTICLE IN A VARIABLE MAGNETIC FIELD. Ioan Stan. Studia Univ. Babes-Bolyai, Ser. 1, No. 1, 279-84 (1961). (In Rumanian)

The movement of a charged particle in an adiabatic variable magnetic field was studied. The H. Geppert method was used, and it is shown that the particle oscillates around the equilibrium position. The trajectories in a constant field and in an adiabatic variable magnetic field are shown. (J.S.R.)

**32794** THE FLUX INVARIANT. Ioan Stan. Studia Univ. Babes-Bolyai, Ser. 1, No. 1, 285-9(1961). (In Rumanian)

It is shown that the flux invariant introduced by Northrop and Teller (Phys. Rev. 117: 215(1960)) is obtained naturally from the "classical" adiabatic invariant $J = \frac{1}{2}\pi \int pdq$ by introduction of variables put in relation to the canonical variables by the use of the intermediate equations $(\dot{\alpha}) = (c)/(eT)\ (\partial J)/(\partial \beta)\ (\alpha_1\ \beta_1\ K_1\ M_1\ t)$, $(\dot{\beta}) = (-(c)/(cT)\ (\partial J)/(\partial \alpha)$. (J.S.R.)

**32795** METHOD OF ANGULAR COLLECTIVE VARIABLES FOR COMPUTING THE STATISTICAL SUM OF A MIXED IONIC-DIPOLE SYSTEM. I. THE CLASSICAL CASE. A. A. Nekrot (Lvov State Univ., USSR). Ukr. Fiz. Zh., 8: 560-8(1963). (In Ukrainian)

A classical system consisting of spatially distributed ions and dipoles is considered. Angular collective variables are introduced for the dipole component of the system, and a function is derived for the transition to these variables. The energy of interaction between the particles is described by Coulomb and dipole potentials, the oscillations and rotations of the dipoles being taken into account approximately. The first approximation is obtained for the free energy of the system, from which the self-congruent ionic part is separated. The latter coincides in form with the Debye free energy of the electrolyte. In this part of the free energy, the presence of the factor $1 + \vec{\beta}(0)$, which has the sense of an incomplete dielectric constant, reflects the screened influence of the dipoles. (auth)

**32796** THE ANALYTIC WAVE FUNCTIONS FOR ATOMS. Tsing-tsuan Kou and Shu-shun Huang. Wu Li Hsueh Pao, 18: 63-71(Feb. 1962). (In Chinese)

The energies of the first ten atoms in the periodic table are calculated with a set of variational wave functions. There are five parameters in all, two for the 1s function, two for the 2s, and one for the 2p functions. One parameter is a scale factor, the best value of which can be determined analytically, leaving but four parameters to be determined numerically. The normalization constant is fixed so that $\psi_2$ is orthogonal to $\psi_1$. The energies and the parameters of the various states are determined by the variational method. (auth)

**32797** CALCULATIONS OF HELICALLY SYMMETRIC MAGNETIC FIELDS. Yung-Nien Ku. Wu Li Hsueh Pao, 18: 572-85(Nov.1962). (In Chinese)

A general expression for the magnetic field created by an infinite helical current distribution is derived by means of a scalar potential method. Formulas for the uniform and symmetric field distribution along the cylindrical surface of conductors are presented. A method of vector potentials is used for conductors of finite length. Results for a corrugated magnetic field produced when the pitch of the helix approaches zero are also presented. (tr-auth)

**32798** SOME PROPERTIES OF OPERATOR IN ELECTROMAGNETIC THEORY. Fu-nien Ku (Kiang Hsi Univ., China). Wu Li Hsueh Pao, 18: 629-35(Dec. 1962). (In Chinese)

The Maxwell equations are studied in inhomogeneous and anisotropic media as an operator. It is defined in a bounded region, which can be comprehended as a resonant cavity in micro-wave technique. But these cavities are filled with ferrite, plasma, or other gyrotropic medium. All these new media become more and more important in practice. It is proved that under some concrete conditions imposed on $\vec{\vec{\mu}}$, $\vec{\vec{\epsilon}}$, and restrictions on the boundary value, the operator of Maxwell's equations becomes a symmetric one. The symmetry and self-adjoint property give much convenience in eigenfunction expansion problems. The orthogonality of characteristic oscillation and reciprocity theorem are derived in general. If the conditions of symmetry are not satisfied, the concept of adjoint-cavity is introduced. The so-called adjoint cavity coincides with the primary cavity in geometrical shape, but both $\vec{\vec{\mu}}$, $\vec{\vec{\epsilon}}$, and boundary conditions do not coincide. It has some properties similar with self-adjoint cavity in orthogonality and reciprocity theorem. (auth)

**32799** ABOUT ONE METHOD OF FINDING THE GREEN TENSOR FUNCTIONS OF ELECTROMAGNETIC FIELD IN ANISOTROPIC MEDIA. Fu-nien Ku (Kiang Hsi Univ., China). Wu Li Hsueh Pao, 18: 636-45(Dec. 1962). (In Chinese)

A method of finding the Green tensor functions in whole space is considered. This method is based on the Fourier transform. Magneto-gyrotropic media and electric-gyrotropic media are considered separately. For magneto-gyrotropic medium, such as ferrite, $\vec{\vec{\mu}}$ is a tensor while $\epsilon$ remains scalar. Conversely, for electric-gyrotropic medium, such as plasma, $\vec{\vec{\epsilon}}$ is tensor and $\mu$ remains scalar. Taking advantage of the smallness of matrix $\vec{\vec{\mu}}$, an expansion in power series of $\vec{\vec{\mu}}_p$ is performed and the calculations in first order approximation are presented. The concrete results are given. The physical meaning of $\Gamma$ and the effective region of the asymptotic expansions are discussed. (auth)

**32800** DETERMINATION OF THE SYMMETRY GROUP OF A QUANTUM SYSTEM ANISOTROPIC OSCILLATOR. Yu. N. Demkov (Leningrad State Univ.). Zh. Eksperim. i Teor. Fiz., 44: 1007-10(June 1963). (In Russian)

The definition of the symmetry group as a group of unitary operators that commute with the hamiltonian is insufficient. Concepts of maximal, minimal, incomplete, and excessive symmetry groups are introduced. A procedure for setting up the minimal symmetry group is proposed. For this purpose it is sufficient to choose a group with the required dimensions of irreducible representations. As an illustration the problem posed by Jauch and Hill is solved. The symmetry group of an anisotropic oscillator is determined. (auth)

**32801** PRODUCTION OF STRONG SHOCK WAVES IN ELECTRIC DISCHARGES IN GAPS. A. E. Voitenko and I. Sh. Model. Zh. Eksperim. i Teor. Fiz., 44: 1760-4 (June 1963). (In Russian)

The velocity of broadening of the spark channel in gaps is investigated. Strong shock waves are obtained in various gases at atmospheric pressure. A shock-wave velocity of 28 km/sec is found in hydrogen. (auth)

**32802** STATE DIAGRAM OF $He^3 - He^4$ SOLUTIONS: STRATIFICATION AND SOLIDIFICATION CURVES. K. N.

Zinoveva. Zh. Eksperim. i Teor. Fiz., 44: 1837-46(June 1963). (In Russian)

Phase stratification curves of liquid $He^3 - He^4$ solutions at high pressures, and solidification curves above the stratification points for various molar concentrations of $He^3$, are measured. The general shape of the state diagram is presented. (auth)

**32803** INVESTIGATION OF THE EFFECT OF HIGH PRESSURE ON THE SUPERCONDUCTING PROPERTIES OF CADMIUM. N. B. Brandt and N. I. Ginzburg (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 44: 1876-83 (June 1963). (In Russian)

The effect of pressures up to 27,000 atm on the critical field curves and temperature $T_c$ for the superconducting transition in cadmium in the 0.08 to 0.5°K temperature range is investigated. A large relative change in $T_c$, about 80% at 26400 atm, is obtained. The possibility of transforming cadmium to the nonsuperconducting state without changing the crystal modification is discussed. (auth)

**32804** OPERATION OF A FOUR-LEVEL OPTICAL GENERATOR. Yu. A. Ananev, V. F. Egorova, A. A. Mak, D. S. Prilezhaev, and B. M. Sedov (State Inst. of Optics, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1884-8(June 1963). (In Russian)

The properties of a four-level optical quantum generator are studied theoretically and experimentally. Conditions for transition from four-level to three-level generation are found for the case of $CaF_2 : U^{3+}$. (auth)

**32805** COVARIANT CONSERVATION LAWS IN THE GENERAL THEORY OF RELATIVITY. D. E. Burlankov. Zh. Eksperim. i Teor. Fiz., 44: 1941-9(June 1963). (In Russian)

For analysis of energy problems in the general theory of relativity, a method is presented of covariant comparison of the investigated space-time with an additional comparison space (plane space is the most convenient); that is, comparative differential geometry is applied. Conservative tensors are derived from the invariance of action relative to motion of the comparison space. The coordinate conditions are replaced by completely covariant correspondence conditions. The relations derived are applied for studying the energy of isolated systems and the Einstein-Rosen waves. (auth)

**32806** ON TAKING INTO ACCOUNT PRESSURE IN THE THEORY OF PHASE TRANSITIONS OF THE SECOND KIND (WITH APPLICATION TO THE CASE OF SUPERCONDUCTIVITY). V. L. Ginzburg (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 44: 2104-6 (June 1963). (In Russian)

The effect of pressure on phase transitions of the second kind is discussed. Specifically, the superconducting transition is considered. (auth)

**32807** ON THE DEVELOPMENT OF A LOCAL QUANTUM FIELD THEORY WITHOUT ULTRAVIOLET DIVERGENCES. G. V. Efimov (Joint Inst. of Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 44: 2107-17(June 1963). (In Russian)

It is suggested that the difficulties of local theory in quantum scalar field theory connected with the presence of ultraviolet divergences in perturbation theory are a result of the circumstance that ordinarily interaction Lagrangians are considered that grow with respect to scalar particle fields $\varphi$ more rapidly than the free field Lagrangian, i. e. as $\varphi^2$. It is found to be possible to introduce such local nonlinear interaction Lagrangians obeying certain conditions for which ultraviolet divergences are absent in the second order of perturbation theory. The correction to the scalar particle mass is computed. (auth)

**32808** STABILITY OF ROTATION OF A SUPERFLUID LIQUID. Yu. G. Mamaladze and S. G. Matinyan (Inst. of Physics, Academy of Sciences, Georgian SSR). Zh. Eksperim. i Teor. Fiz., 44: 2118-21(June 1963). (In Russian)

It is shown that the region of stability of stationary motion of a superfluid liquid rotating between two coaxial cylinders is broader than that corresponding to an ideal classical liquid. This result is a consequence of the stabilizing effect of quantized vortex lines. The result obtained is in agreement with experiment. (auth)

**32809** HOLLOW SUPERCONDUCTORS IN A MAGNETIC FIELD. Lung-Tao Su and G. F. Zharkov (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 44: 2122-30(June 1963). (In Russian)

Formulas are obtained, within the framework of the Ginzburg–Landau theory of superconductivity, which describe the behavior in a magnetic field of superconducting samples in the form of a hollow sphere or a hollow cylinder. The critical magnetic fields of such samples are found. The limits of possible "superheating" or "supercooling" are determined. Destruction of the superconductivity of a hollow cylinder by a current is also considered. (auth)

**32810** ATOMIC PHOTOEFFECT AT HIGH ENERGIES. V. G. Gorshkov and A. I. Mikhailov (Ioffe Inst. of Physics and Tech., Leningrad). Zh. Eksperim. i Teor. Fiz., 44: 2142-9(June 1963). (In Russian)

It is shown that in the extreme relativistic case the main contribution to the photoeffect cross section is from the wave function of the ejected electron, which is of the form of a Schrödinger equation solution with an energy E equal to the momentum p. The error in the cross section in this case may be of the order of $E^{-2}$. It is proven that at high energies, calculations based on the Schrödinger equation solution and on a distorted plane wave lead to identical results. An analytical formula for the cross section at small angles is obtained. The limiting nuclear charge Z after which the peak in the angular distribution coincides with zero angle is also determined. (auth)

**32811** NON-EQUILIBRIUM DISTRIBUTION OF ENERGY ACCORDING TO THE DEGREE OF MOLECULAR FREEDOM IN DISTURBED MAXWELLIAN DISTRIBUTION. A. I. Osipov and E. V. Stupchenko. Zh. Prikl. Mekhan. i Tekhn. Fiz., No. 3, 41-4(May-June 1963). (In Russian)

Fluctuating energy distribution in a gas disturbed by a source of fast particles was studied. A function of quasi-stationary, non-equilibrium energy distribution was determined according to fluctuating degrees of freedom in gases. The problem is applicable in hot atom chemistry and in reactions producing fast particles. (R.V.J.)

**32812** CONVECTION INSTABILITY OF COMPRESSED FLUID IN MAGNETOHYDRODYNAMICS. A. A. Rukhadze. Zh. Prikl. Mekhan. i Tekhn. Fiz., No. 3, 139-42(May-June 1963). (In Russian)

A problem on convective instability in compressed, ideally conducting fluid in a gravitational field was resolved by optical approximation. The derived dispersion equations were analyzed at high and low oscillation frequencies. It is shown that in gravitational fields the conducting fluid is stable only in relation to low frequency oscillations. Conditions of instability generalizing the known criteria of convection instability were determined. (R.V.J.)

**32813** STEADY FLOW OF CONDUCTING FLUID IN RECTANGULAR CHANNEL IN TRANSVERSE MAGNETIC FIELD. O. A. Berezin. Zh. Prikl. Mekhan. i Tekhn. Fiz., No. 3, 155-9(May-June 1963). (In Russian)

A problem of steady conducting fluid flow in a rectangular channel with ideally conducting side walls ($y = \pm a$) and nonconducting upper and lower walls ($z = \pm l$) was reduced to an infinite system of algebraic equations, resolved by subsequent approximations. An approximate resolution was also derived for problems with large Hartman numbers. (R.V.J.)

**32814** EFFECTS OF MAGNETIC FIELDS ON THE OPTIMUM COMPOSITION OF ELECTROCONDUCTIVITY. E. P. Zimin and V. A. Popov. Zh. Prikl. Mekhan. i Tekhn. Fiz., No. 3, 162-4(May-June 1963). (In Russian)

In the presence of magnetic field, electric conductivity becomes a function of magnetic field intensity and is anisotropic in character. The electric conductivity as a function of magnetic field was estimated for gaseous mixtures of Ar + Cs, He + Cs, and $CO_2$ + Cs and for a pure cesium (at 0.1, 1.2, and 10 atm pressure and T = 3000°K). It was found that anisotropic conductivity in mixed gases develops at lower fields than in pure cesium. However, at fields of $H < H_m$ electric conductivity of any of the examined mixtures is higher than that of pure cesium. (R.V.J.)

**32815** NUCLEAR CHEMISTRY. Noah R. Johnson, Eugene Eichler, and G. Davis O'Kelley. Technique of Inorganic Chemistry, Volume II. New York, Interscience Publishers, 1963. 211p. $8.00.

A review is presented of radioactive decay, interactions of radiations with matter, radioisotope production, separation techniques, radiation detection and measurement, source mounting, and research related to radioactivity. (T.F.H.)

**32816** ELECTRON-ION-ATOM THREE-BODY RECOMBINATION. Ernest Bauer and E. R. Buley (Aeronutronic. Div. Ford Motor Co., Newport Beach, Calif.). 27p. (CONF-22-19)

From American Physical Society Meeting, New York, Jan. 1963.

The rate for the three-body recombination of an electron and an oxygen atomic ion, with a nitrogen atom acting as third body that takes up the excess energy, was calculated by the quantum mechanical distorted wave method. The calculation was performed numerically on IBM 7090 computers for electron and heavy particle energies below 1 ev, and for the electron captured into states characterized by principal quantum numbers n = 6, 10. The results for the recombination coefficient summed over all possible orbital quantum numbers of the bound electron are $10^{-28}$ $cm^6/sec$ for n = 6 and $10^{-28}$ $cm^6/sec$ for n = 10. (auth)

**32817** THEORETICAL PERFORMANCE OF MHD GENERATORS UTILIZING MAGNETICALLY INDUCED NON-EQUILIBRIUM IONIZATION IN PURE ALKALI METAL VAPORS AND IN SEEDED GAS SYSTEMS. F. H. Shair (General Electric Co., King of Prussia, Penna.). 16p. (CONF-24-3)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

Theoretical calculations were completed to determine the relative performance of MHD generators utilizing non-equilibrium ionization in all the pure alkali metal vapors, in helium seeded with lithium, and in systems of hydrogen, argon, and mercury, seeded with cesium. The MHD generator performance calculations are based upon one-dimensional steady state flows with constant Mach number, and in which the dimer concentration is negligible. The electrodes in the generator are assumed to be segmented. Potassium appears to be the best choice among the alkali metal series for a 1 megawatt generator operating at total temperatures of about 1600°K and total pressures near 20 psia. This choice is based upon considerations of the calculated generator performance, the vapor pressure, and the equilibrium concentration of dimer in the vapor. The influence of the total temperature, total pressure, Mach number, ionization potential, atomic weight, elastic electron collision cross section, and magnetic field strength upon electron temperature, plasma conductivity, and power density was determined. The calculations show that the performance of an MHD generator utilizing a non-equilibrium condition of the electrons is primarily dominated by the elastic electron-neutral collision cross section. Due to much smaller elastic electron collision cross sections in hydrogen, helium, argon, and mercury, as compared to that of the alkali metals, the electron temperatures, plasma conductivities and power densities are generally higher in the former group as compared to the equivalent systems of the latter group. It is possible to operate the argon-cesium system in the subsonic region. A magnetic field of 20,000 gauss produces a power density of 0.5 $KW/cm^3$. The electron temperature is 3700°K and 50% of the seed is ionized. The plasma conductivity is around 550 mhos/meter. The calculations also show the optimum mole fraction of seed to be much less in the case of non-equilibrium plasmas, than in the case of equilibrium plasmas. Particularly interesting is the insensitivity of the relation between the plasma conductivity and electron temperature to the total gas temperature, to the total gas pressure, the Mach number and even the mole fraction of seed; thus measurements of plasma conductivity in non-equilibrium systems provide an indirect but accurate measurement of the electron temperature. (auth)

**32818** MAGNETIC RELAXATION IN RARE EARTH SALTS. A. H. Cooke and E. J. Daintree (Oxford Univ.). 7p. (CONF-20-26)

From Rare Earth Conference, Clearwater, Fla., Apr. 1963.

Experiments were made on spin-lattice relaxation in rare earth salts in the helium range of temperatures. It is found that at the lowest temperatures, at which relaxation by the "direct" one-phonon process would be expected to predominate, the relaxation time derived from measurements by the Casimir-Du Pré low-frequency method departs in several ways from the predictions of theory; in particular, it increases with magnetic field. It is shown that these features can be accounted for if allowance is made for variations of the temperature of the phonons in contact with the spin system, due to a "phonon bottleneck," of the type postulated by Scott and Jeffries. (auth)

**32819** MAGNETIC MOMENTS AND IRON NUCLEAR HYPERFINE FIELDS IN LAVES PHASES CONTAINING LANTHANIDES COMBINED WITH IRON AND COBALT. W. E. Wallace and E. A. Skrabek (Univ. of Pittsburgh). 14p. (CONF-20-25)

From Rare Earth Conference, Clearwater, Fla., Apr. 1963.

Studies were made of the series of compounds represented by the formula $AFe_2$ and $ACo_2$. A in the $AFe_2$ series is Y, Sm, Tb, Ho, Er, Tm, and Lu and in the $ACo_2$ series is this group and in addition Ce, Pr, Nd, Gd, and Dy. These compounds are all isostructural possessing the $MgCu_2$ structure. All of these except $CeCo_2$ and $LuCo_2$ exhibit

Curie points at temperatures ranging from 33°K for $TmCo_2$ to 705°K for $TbFe_2$. $CeCo_2$ and $LuCo_2$ remain paramagnetic to 4.2°K and seem to be simply Pauli paramagnetics. Thus in these materials cobalt is non-magnetic and Ce is ionized to the quadripositive state. Saturation magnetizations were determined at 300°K and at the liquid helium and nitrogen points. Results for $YCo_2$ and $GdCo_2$ indicate Co moments of about 0.1 and 1.3 $\mu_B$ per atom in the former and latter, respectively. Thus, the cobalt moment is variable in the $ACo_2$ series. Saturation magnetizations of $YFe_2$ and $LuFe_2$ indicate an Fe moment of about 1.45 $\mu_B$. Nuclear hyperfine fields (measured by use of Mössbauer effect involving $Fe^{57}$) vary from about $1.5 \times 10^5$ to $1.9 \times 10^5$ Oe for several members of the $AFe_2$ series. From this and the measured moments it is concluded that the Fe moment varies but not as extensively as the cobalt moment in the $ACo_2$ series. Measured moments of the iron compounds do not correspond with either ferromagnetic or antiferromagnetic coupling of the Fe and lanthanide moments if the latter are taken to be those of the free tripositive ion. This is taken to imply some crystal field quenching of the lanthanide moments but less than in the $ANi_2$ and $ACo_2$ series. (auth)

**32820** ORBITS IN A LOGARITHMIC POTENTIAL. R. H. Hooverman (Univ. of Wisconsin, Madison). 20p. (CONF-46-20)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

The characteristics of charged particle orbits in the logarithmic electrostatic potential field surrounding a straight conducting wire at a fixed potential are investigated. The equations of motion of an electron in a logarithmic potential are derived, the limiting cases are considered, and the results of numerical integration of the equations of motion are presented along with sketches of a few representative orbits. (C.E.S.)

**32821** CALCULATION OF THE SURFACE TEMPERATURE OF A SOLID UNDER ELECTRON BOMBARDMENT. G. E. Vibrans (Massachusetts Inst. of Tech., Lexington). 19p. (CONF-57-1)

From 5th Electron Beam Symposium, Boston, Mar. 1963.

The temperature on the surface of any solid under electron bombardment can be calculated by classical means if the thermal properties and the energy dissipation within the range of the electrons are known. Two different dissipation functions were assumed, both of which have some theoretical justification. The surface temperature computed with these two assumptions is compared in two normalized diagrams. The first dissipation function is derived from range measurement, while the second is taken from the computations of L. V. Spencer. The method of heat flow computation is explained and it is shown that any new solid or any better value of thermal properties can be introduced by using two new scaling factors. (auth)

**32822** THE HOLLOW CATHODE DISCHARGE. John R. Morley (Alloyd Electronics Corp., Cambridge, Mass.). 10p. (CONF-57-5)

From Electron Beam Symposium, Boston, Mar. 1963.

A high current, low voltage, magnetically confined electron beam is discussed in terms of its operation and performance. A low pressure gas plasma cathode supplies up to 1000 amps of electron emission. The beam is operated at 30 to 50 volts providing approximately 40 kw of power. Chamber pressures between $10^{-4}$ to $10^{-2}$ Torr of an inert gas are maintained. Various shapes of electron beam are reported. Information on strip annealing of copper and of casting steel ingots is presented. (auth)

**32823** NON-ADIABATIC EFFECTS IN THE HIGH-ENERGY SCATTERING OF NORMAL HELIUM ATOMS. Walter R. Thorson (Massachusetts Inst. of Tech., Cambridge). 34p. (CONF-76-2)

From Symposium on Molecular Structure and Spectroscopy, Columbus, Ohio, June 1963.

There is a large discrepancy between the calculated adiabatic electronic energy of the ground state of the system $He_2$ and the effective scattering potential deduced from experiments with high energy (2 kev) atomic beams, at small interatomic distances. It is shown that at least a significant part of this discrepancy arises from non-adiabatic effects of high relative angular velocity of the atoms in the collisions typical of the experiment. A perturbation theory treatment is included to give an estimate of the overall magnitude of the effect; but a variational calculation is employed with the non-adiabatic hamiltonian to produce the minimum estimates of non-adiabatic energy shifts. The theory correctly predicts the observed approximate agreement between adiabatic energies and the experimental potentials at larger distances (1.06 A.). A method of extending the variational calculation to include continuum contributions is described; it employs a pseudo hamiltonian to simplify the calculation. Arguments connected with this formulation are advanced to suggest that when continuum contributions are taken into account it may be possible to account for all or most of the observed discrepancy. (auth)

**32824** PERFORMANCE OF, AND ENTROPY PRODUCTION IN, MHD SPACE POWER CYCLES. Steven I. Freedmann (General Electric Co., King of Prussia, Penna. and Massachusetts Inst. of Tech., Cambridge). 42p. (CONF-24-10)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

The thermodynamic performance of MHD gas and vapor power cycles is analyzed in terms of the temperature limited components. The power generation is optimized for minimum radiator area. Brayton and Joule cycles are compared with Rankine cycles. Thermodynamic performance of two-fluid combined Rankine and Brayton cycles is obtained. The superiority of Rankine cycles over the Brayton cycle and two-fluid combined Rankine and Brayton cycle is shown. Entropy generation in supersonic MHD generators was analyzed. Local stage efficiencies were computed from knowledge of the loading factor and Mach number. Overall, polytropic efficiencies were computed from the stage efficiencies and pressure ratio. Diffuser losses were correlated with diffuser inlet Mach number. Entropy generation in the diffuser was analyzed. Overall device performance is presented in terms of an equivalent turbine efficiency, including diffuser losses. Results show that the reduction of efficiency attributed to differences between stagnation and static temperatures are of the same order of magnitude as the increase in efficiency due to the reheat factor for typical situations. Diffuser losses become excessive at Mach numbers greater than 2 to 3. Slightly supersonic, M = 1 to 1.5, MHD generators appear not to be hampered by diffuser losses. (auth)

**32825** A COMPARISON OF THE CONTACT IONIZATION OF CESIUM ON TUNGSTEN WITH THAT OF MOLYBDENUM, TANTALUM, AND RHENIUM SURFACES. O. K. Husmann (Hughes Research Labs., Malibu, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63019, 27p. (CONF-10-31)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Surface ionization of cesium on porous tungsten, rhenium,

molybdenum, and tantalum is reported in light of the ionization efficiency and the critical emitter temperature up to current densities of 10 ma/cm$^2$. Results from the porous materials are compared with solid surface data. The neutral detector characteristics are discussed. The power efficiency of the ion engine depends strongly on the critical temperature of the emitter. These temperatures are presented for the four refractory materials and the spectral emissivities of the porous materials are listed. Comparison of porous tungsten, rhenium, molybdenum, and tantalum up to ion current densities of 10 ma/cm$^2$ indicates the superiority of tungsten with respect to the critical temperature and the related power efficiency. Power efficiencies for clean and oxygenated porous tungsten are computed taking into consideration beam power and radiation losses. By introducing oxygen into the ultra high vacuum system the ionization efficiency can be increased. If carbon is present on the heated parts it can be detected as $CO_2$ and CO; the time of desorption of oxygen from the emitter surface is short in comparison with the time of engine operation. The proportionality factor between statistically evaluated and measured transmission coefficient may be explained as tortuosity and is connected with the consolidation of the porous material. Monitoring five different porous tungsten pellets at their critical temperatures for 10 ma/cm$^2$ cesium ion current density, for over 10 months allows preliminary extrapolation of life expectancy. (auth)

**32826** SLOWING DOWN OF FAST ELECTRONS. D. Harder, H. Feist, and A. Rausche. 6p. (CONF-19-2)

From International Congress of Radiation Research, Harrogate, Eng., Aug. 1962.

Experimental and theoretical analyses of electron slowing-down spectra are discussed for initial energies of 1 kev to 10 Mev. Spectra in water and Pb are shown as examples. (T.F.H.)

**32827** INVESTIGATIONS OF THE MIGRATION, DESORPTION AND VOLTAGE BREAKDOWN PROPERTIES OF CESIUM FILMS ON REFRACTORY ELECTRODES. F. M. Charbonnier, L. W. Swanson, E. C. Cooper, and R. W. Strayer (Field Emission Corp., McMinnville, Ore.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63020, 49p. (CONF-10-32)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Investigation, by pulse field emission microscopy, of the behavior of cesium films on tungsten, molybdenum and rhenium is discussed. Thermal desorption and work function measurements of these three systems as a function of degree of coverage have been performed and show many interesting similarities such as a work function minimum of similar value occurring for all three systems, a striking redistribution in the electron emission pattern at the work function minimum, a high coverage work function approaching that of bulk cesium, and a decreasing heat of adsorption with increasing cesium coverage. Preliminary results of the migration of cesium at various initial coverages also show many similarities in both the migration temperatures and the effect of substrate crystallographic orientation on the mode of surface migration. Application of a d-c electric field of either polarity is found to produce a significant decrease in the activation energy for surface diffusion of cesium on tungsten. A related investigation of the prebreakdown currents between cesium coated tungsten electrodes, both in high vacuum and cesium pressures of $10^{-6}$ Torr, is discussed; results of current measurements, at various electrode spacings and at applied voltages up to 13 kv, indicate stable, reproducible field emission as the principal source for the gap currents observed, at least at the voltage gradients investigated. (auth)

**32828** EFFECTS OF LIQUID-SOLID INTERFACES ON THE NUCLEATION CHARACTERISTICS OF CRYOGENIC LIQUIDS. Jesse Hord, C. C. Robinson, and L. L. Sparks (National Bureau of Standards, Boulder, Colo.). New York, American Society of Mechanical Engineers, (1963), Preprint 63-AHGT-45, 8p, $1.00. (CONF-7-3)

From Aviation and Space, Hydraulic, and Gas Turbine Conference and Products Show, Los Angeles, Mar. 1963.

The effects of some liquid-solid interfaces on the nucleation characteristics of superheated $LN_2$ and $LH_2$ are presented. Nucleation of the vapor phase in a static, metastable cryogenic liquid, is enhanced by fluid contamination and rough environmental surfaces. The nucleation pressure of a given cryogenic liquid is relatively independent of the type of contaminating material. With all environmental materials tested, a surface finish smoother than 70 μin. was required to prevent an increase in the nucleation pressure. An increase in nucleation pressure is evidenced by a shifting of the superheat-limit curve away from that of the nearly ideal system toward the liquid-vapor equilibrium curve. In general, the effect of fluid contamination and nonideal liquid-solid interfaces is to greatly reduce the presistence time of the metastable state. (auth)

**32829** THE SECONDARY EXTINCTION CORRECTION. W. H. Zachariasen (Univ. of Chicago). 21p. (CONF-64-2).

From American Crystallographic Assn. Meeting, Cambridge, Mass., Mar. 1963.

It is shown that Darwin's formula for the secondary extinction correction, which has been universally accepted and extensively used, contains an appreciable error in the x-ray diffraction case. The correct formula is derived. As a first order correction for secondary extinction, Darwin showed that one should use an effective absorption coefficient $\mu + gQ$ where an unpolarized incident beam is presumed. The new derivation shows that the effective absorption coefficient is $\mu + 2gQ(1 + \cos^4 2\theta)/(1 + \cos^2 2\theta)^2$, which gives $\mu + gQ$ at $\theta = 0°$ and $\theta = 90°$, but $\mu + 2gQ$ at $\theta = 45°$. Darwin's theory remains valid when applied to neutron diffraction. (auth)

**32830** CESIUM COMPOUND SEMICONDUCTORS AS LOW THERMIONIC WORK FUNCTION COLLECTORS IN THERMIONIC ENERGY CONVERTERS. R. A. Chapman, H. J. Caulfield, and H. W. Hemstreet (Texas Instruments Inc., Dallas). 18p. (CONF-46-12)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

The thermionic work function of films of cesium reaction products with antimony, tellurium, and silicon on nickel and tantalum substrates was studied in the presence of cesium vapor with reservoir temperatures as high as 110°C. These films ranged in thickness from 300 Å to 10,000 Å. Several of the films can be interpreted as cesium compound semiconductors with doping by excess cesium. The thermionic work function was measured by both emission measurements and diode contact potential difference techniques with most emphasis of the latter technique. In the case of the cesium–antimony and cesium–tellurium films, the minimum work functions were in the range of $1.2 \pm 0.1$ ev. The cesium–silicon film was found to have a thermionic work function near 1.7 ev. The effects of chemical impurities and film thickness were investigated. (auth)

**32831** ON THE CHOICE OF COORDINATES USED TO DESCRIBE THERMOELECTRIC AND THERMOMAGNETIC GENERATORS. J. F. Osterle and S. W. Angrist (Carnegie

Inst. of Tech., Pittsburgh). New York, American Society of Mechanical Engineers, 1963, Preprint 63-APM-19, 4p. (CONF-6-1).

From Conference, Ithaca, N. Y., June 1963.

It is demonstrated that the form of the energy-dissipation equation which describes thermoelectric and thermomagnetic generators is greatly dependent on the choice of dependent variables in the coupled equations used to describe the devices. If "natural" coordinates are chosen, the energy dissipation will always contain two terms—the Fourier conduction term and Joulean heating term. If "unnatural" coordinates are chosen, the energy-dissipation equation will contain three terms. A brief solid-state consideration demonstrates how a bound on the figure-of-merit temperature product can arise in terms of fundamental physical parameters. (auth)

**32832** ON THE BOUNDEDNESS OF THE DIMENSIONLESS INDEX OF PERFORMANCE OF A NERNST EFFECT GENERATOR. S. W. Angrist (Carnegie Inst. of Tech., Pittsburgh). New York, American Society of Mechanical Engineers, 1963, Preprint 63-APM-4, 4p. (CONF-6-5).

From Conference, Ithaca, N. Y., June 1963.

In an earlier paper, a Nernst effect generator was analyzed by the usual thermodynamic methods and it was found that a bound of unity arises on the dimensionless quantity $\theta T$ where $\theta$ is given as the square of the product of the Nernst coefficient and magnetic field divided by the thermal conductivity and electrical resistivity. By application of the appropriate equations of semiconductor theory, this bound is shown to be justified for four limiting cases: weak magnetic fields considering both extrinsic and intrinsic materials, and strong magnetic fields considering both extrinsic and intrinsic materials. (auth)

**32833** POSITIVE TEMPERATURE COEFFICIENTS AND SATURATION OF LUMINESCENCE OF ZnS SINGLE CRYSTALS USING EXCITATION BY ELECTRONS. W. Klein. Thesis, Berlin, Freie Universität, 1962. 113p. $2.00.

The influence of temperature and intensity on the luminescence of ZnS single crystals in various emission bands after excitation with 60-kev electrons is studied. The luminescence yield of the green and blue emission bands increases for increasing temperatures, reaches a maximum, and decreases at high temperature. The yield is independent of excitation intensity in the region of negative temperature coefficients. For positive temperature coefficients the yield is inversely proportional to the square root of the intensity. A theoretical explanation of this effect using Riehl-Schoen theory is given. The saturation of luminescence is studied. The results indicate that for ZnS no real saturation effect exists. (Gmelin Inst.)

**32834** TRAP PROPERTIES OF ELECTROLUMINESCENT ZnS PHOSPHORS. W. Kernchen. Thesis, Berlin, Freie Universität, 1962. 69p. $2.00.

The occupation of traps in electroluminescent ZnS phosphors by field excitation at low temperatures is studied. The results indicate that trap occupation for field excitation is only 1/1000 of that for UV excitation. Explanations for this effect are given. Voltage and frequency dependences of trap occupation and of electroluminescence are not the same. The different behavior can be explained by assuming an occupation of traps by diffusion. The construction of an apparatus for the measurement of frequency factors for frequencies up to 2 Mc is described. (Gmelin Inst.)

**32835** PERFORMANCE AND ANALYSIS OF A CROSSED-FIELD ACCELERATOR. G. R. Russell, S. Byron, and P. I. Bortz (Ford Motor Co., Newport Beach, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63-005, 40p. (CONF-10-33).

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

A theoretical and experimental study was made of a steady supersonic free jet crossed field accelerator, using monatomic gases. A two fluid model is used to compute the non-equilibrium gas properties in the supersonic nozzle and in the accelerator section. Solutions for the supersonic nozzle expansion were obtained for the limiting cases of an optically thin and an optically thick plasma. The non-equilibrium accelerator theory was solved for the variation of the plasma properties in the direction of the flow and perpendicular to the flow. A simpler one-dimensional theory of constant pressure supersonic crossed field acceleration is presented for the limiting cases of frozen and equilibrium electron densities and is compared with experimental results. In the experimental study, acceleration was produced in argon by adding up to 70 kilowatts of electrical power for a duration of up to three hours to the supersonic flow in the presence of a transverse magnetic field ranging from 700 to 2500 gauss. Calorimetric measurements, direct free stream velocity measurements, and static and total pressure measurements were made. (auth)

**32836** PROTOTYPE NUCLEAR-FUELED THERMIONIC CONVERTER TEST. W. L. Orr, R. M. Ball, and H. J. Worsham, Jr. (Babcock and Wilcox Co., Lynchburg, Va.). 16p. (CONF-39-13)

From American Nuclear Society Meeting, Salt Lake City, June 1963.

Results are reported of heat-transfer experiments and of a 300-hr in-pile test of a 150-watt thermionic converter using fission heat. In the in-pile test, the electrical output began to reduce slightly after 250 hr and became zero after 300 hr. (D.L.C.)

**32837** CHARGE EXCHANGE REACTIONS. Wade L. Fite (General Atomic Div., General Dynamics Corp., San Diego, Calif.). 15p. (CONF-74-10; GA-4322)

From Conference on Mass Spectrometry and Allied Topics, San Francisco, May 1963.

The processes wherein the charges on two colliding particles are altered and the experimental methods used to study these processes are reviewed. In the high-energy range, a comparison is made between the equilibrium beam method of determining neutralization and stripping cross sections and the slow ion detection methods used to study charge transfer. Thermal energy reactions that were studied using afterglow mass spectrometers are reviewed and the results of various laboratories are compared. After summarizing outstanding problems pertaining to charge exchange reactions, some consideration is given to the effects of these reactions in other mass spectrometer applications. (auth)

**32838** NEGATIVE-ION PRODUCTION FROM BEAMS OF 35-200 kev POSITIVE-IONS. N. Burn, P. G. Ashbaugh, and A. E. Litherland [Atomic Energy of Canada Ltd., Chalk River, Ont.]. 10p. (CONF-46-50)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

Positive ions were accelerated with a vertical Van de Graaff machine and were passed into an exchange canal through which hydrogen flowed. The emerging beam was electrostatically analyzed. Equilibrium fractions for $He^4$, $O^{16}$, and $C^{12}$ in H were measured. The fractions for $C^{12}$ and $O^{16}$, as a function of energy, had maximums of 3.2% at 120 kev and 12.3% at 50 kev, respectively. Growth of negative

ion beams ($O^{16}$ and $He^4$) and decay and growth of positive and neutral beams ($O^{16}$ and $He^4$), were plotted, and charge exchange cross sections for $He^4$ and $O^{16}$ at 150 kev in H were determined. (D.C.W.)

**32839** CRITICAL CURRENT AND ELECTRON DEPAIRING IN SUPERCONDUCTING FILMS. Peter Fulde and Richard A. Ferrell (Univ. of Maryland, College Park). 10p. (CONF-46-64)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

A procedure for exploring the depairing region where electron pairs break up into quasi-particle excitations is described. The depairing phenomenon sets in at certain electron pair momenta and is accompanied by a decrease in the superconducting current. The depairing also provides a gradual (not abrupt) loss of superconducting coherence and a second order transition, permitting study of the superconducting state. (D.C.W.)

**32840** METHOD OF PRODUCTION OF A PULSED ION BEAM AND DEVICES FOR THE PRACTICAL APPLICATION OF THE SAID METHOD. (to Commissariat a l'Energie Atomique). British Patent 931,044. July 10, 1963. Priority date Mar. 30, 1961, France.

A method of producing a pulsed ion beam, when the ion-production space is subjected to a high-frequency electric field to increase the probability of ionization, is patented. The pulsation is generated by alternately creating and suppressing the electric field. The oscillator providing the electric field can be blocked and unblocked by coupling a square-wave generator to it, thereby pulsing the ion beam. (M.P.G.)

**32841** IMPROVEMENTS IN OR RELATING TO ION GUNS. Noel Azam (to Commissariat a l'Energie Atomique). British Patent 931,750. July 17, 1963. Priority date Apr. 2, 1959, France.

The design of a high-efficiency ion gun capable of producing intense streams of ions is patented. The gun has a hollow anode containing a gas or vapor under a vacuum of the order of $10^{-1}$ mm Hg. A cathode surrounds the anode, and the part of the cathode opposite the open end of the anode is a grid, which separates the space in which the ions are produced from the space in which the ions are utilized. The ion-production space and the ion-utilization space are at the same pressure. The stream of ions may be made cylindrical, convergent, or divergent according to the shape of the grid, which is removable. A dished, reversible grid makes it easy to change from a convergent to a divergent stream. (M.P.G.)

**32842** APPARATUS FOR USE IN DETERMINING PARTICLE SIZE AND DISTRIBUTION OF PARTICLE SIZE. Seymour Z. Lewin (to Evans Research and Development Corp.). U. S. Patent 3,098,931. July 23, 1963. Filed Mar. 4, 1959.

A method and apparatus are described for determining the particle size and/or distribution of particle size in compositions with randomly distributed particles. A radiation beam sensitive to the several phases of the specimen is passed through a known volume of the specimen. The attenuation of the radiation beam is measured and compared with similar data from the same volume of a specimen of known particle size and/or distribution. The preferred source of radiation is a radioisotope. Either back-scattered or transmitted radiation can be measured. The determination can be made without physically removing samples from the specimen. (A.G.W.)

**32843** METHOD FOR REDUCING THE IMPURITY RESISTIVITY OF SODIUM. Richard F. Post and C. E. Taylor (to U. S. Atomic Energy Commission). U. S. Patent 3,100,730. Aug. 13, 1963.

The inherent resistivity of sodium, at cryogenic temperatures, can be reduced by clustering the impurity atoms within the crystal lattice structure of the sodium, thereby reducing the effective electron collision cross section and thus reducing the number of collisions between the electrons and such lattice imperfections. The clustering is effected by heating the sodium to a temperature approaching its melting point, and maintaining the temperature for a period of time ranging generally from two to six days. (AEC)

## Astrophysics, Cosmology, and Geophysics

**32844** (ARF-A218-12) WAVE PROPAGATION UNDER ANOMALOUS CONDITIONS. MEASUREMENT OF THE CHARGE NEUTRALIZATION RATE BETWEEN $NO^+$ AND $O_2^-$. Quarterly Report No. 3, December 15, 1962–March 15, 1963. Carsten M. Haaland (Illinois Inst. of Tech., Chicago. IIT Research Inst.). Apr. 1963. Contract DA-36-039-SC-90762. 8p.

A program designed to measure the charge neutralization coefficient between the predominant positive and negative ions of the lower D region of the atmosphere is discussed. The features of the redesigned acceleration system indicate that the two mechanical shutters are to be activated by three long rods, which pass from vacuum into the ambient atmosphere, where they receive motion by impact of a bullet on a plate fastened to the rear end of the rods. The features and design of a simplified bakable valve for ultrahigh vacuum systems are given. (N.W.R.)

**32845** (UCRL-7309(Rev.I)) SPECTRA AND FLUXES OF ELECTRONS TRAPPED IN THE EARTH'S MAGNETIC FIELD FOLLOWING RECENT HIGH ALTITUDE NUCLEAR BURSTS. H. I. West, Jr., L. G. Mann, and S. D. Bloom (California. Univ., Livermore. Lawrence Radiation Lab.). Apr. 10, 1963. Contract W-7405-eng-48. 28p.

Electron spectral measurements were made in the fall 1962 in the following energy channels: 325, 955, 1630, 2400, and 3250 kev. A high altitude event (L = 1.8-3) was observed on October 28 and data were obtained for several days afterwards. The spectra do not resemble a fission spectrum. Electron distributions observed at L ~ 1.8 to 2.2 near the equator were peaked ~35° to the field direction. Electrons from Starfish were observed, and do resemble an equilibrium fission spectrum. Angular distributions ~14° from the geomagnetic equator were ~20° wide (full width at half maximum). Isotropic fluxes in this region were ~$10^8$ electrons/$cm^2$/sec at the end of October. Measurements December 8 near the geomagnetic equator gave isotropic fluxes of ~$3 \times 10^8$ electrons/$cm^2$/sec with distributions ~50° wide. (auth)

**32846** (UCRL-13084) THE INITIAL-FIELDS SPECIFICATION PROBLEM. Technical Summary Report. Manfred M. Holl (Meteorology International Inc., Monterey, Calif.). June 1963. For Univ. of California Lawrence Radiation Lab., Livermore. Contract W-7405-eng-48. 19p.

Formulation of the initial conditions for calculations on the evolution of the state of the atmosphere so that extraneous disturbances (compression-gravity, for instance) can be minimized is treated. An approach is developed, and an

experimental program for comparing techniques of initial-value specification is advanced. (D.C.W.)

**32847** OPTICAL IDENTIFICATION OF 3C 48, 3C 196, AND 3C 286 WITH STELLAR OBJECTS. Thomas A. Matthews (California Inst. of Tech., Pasadena) and Allan R. Sandage. Astrophys. J., 138: 30-56(July 1, 1963).

Radio positions of the three sources were determined with the two 90-foot antennas working as an interferometer with an rms accuracy in both co-ordinates better than 10 seconds of arc. Direct photographs show that a starlike object exists within the error rectangle at each of the source positions. Exceedingly faint wisps of nebulosity are associated with the stars in 3C 48 and 3C 196. The observations are incomplete for 3C 286 in this regard. Photoelectric photometry of the stars shows each to have quite peculiar color indices, most closely resembling the colors of old novae or possibly white dwarfs, but identification with these types of stars is not suggested. Photometry of 3C 48 through 13 months shows the star to be variable by at least $\Delta V = 0^m.4$. The radio flux appears to be constant. Optical spectra for 3C 48 show several very broad emission features, the most intense at λ 3832 being unidentified. Spectra by Schmidt of 3C 196 and 3C 286 show other unusual features. The radio structure of the three radio stars is similar in that each has an unresolved core of <1″ diameter. However, 3C 196 and 3C 286 show halos of 12″ and 20″, respectively, while no radiq halo was detected for 3C 48. It is shown that the radiant flux in the optical region can be computed from the radio-flux data and the theory of synchrotron radiation for 3C 48 and 3C 196, but not for 3C 286. This, together with other arguments, suggests that the optical as well as the radio flux could be due to the synchrotron mechanism, but the arguments are not conclusive. The assumption of minimum total energy was used to compute the energy in relativistic particles and magnetic field required by the synchrotron mechanism to explain the observed emission. The magnetic field in each of the core components is near 0.1 gauss and depends mainly on the assumed angular size of the emitting region. The total energy in the core components is near $10^{60}$ ergs. The rate of radiation is such that the energy in relativistic electrons must be replaced in a time scale of a few years if the value of the magnetic field determined in this way is correct. These calculations are based on a distance of 100 pcs. The frequency of occurrence of radio stars is examined, and they are estimated to comprise from 5 to 10 per cent of sources in the 3C catalogue. The percentage is likely to be less for fainter sources. Rough limits were estimated for the mean distances of these radio stars. A mean distance of approximately 100 pc is suggested if these objects are in the galaxy. Evidence obtained suggests that 3C 48 has a large redshift of z = 0.3675; thus these objects may be associated with a distant galaxy. The absolute magnitude of the starlike objects is $M_v = -24.3$, which is much brighter than any other galaxy. As a radio source, 3C 48 is not very different from other identified sources. The emitted flux is the same as 3C 295 and Cygnus A, but the emitting volume is much less. The faint nebulosity does not resemble a galaxy, and it also is brighter than a normal galaxy. If caused by an explosion in the past and expanding at the velocity of light, its age would be $\geq 1.8 \times 10^5$ years. The synchrotron lifetime calculated in the normal manner is much shorter than that inferred from the extent of the faint nebulosity. Thus either the magnetic field must be much lower than calculated, or high-energy electrons must be supplied continuously. (auth)

**32848** THE GALACTIC HALO—A TRANSIENT PHENOMENON. G. R. Burbidge (Univ. of California, San Diego) and F. Hoyle. Astrophys. J., 138: 57-61(July 1, 1963).

The properties of galactic halos of radio emission and models that were proposed to account for the condition of our own galactic halo are briefly reviewed. A new model is then proposed in which it is argued that the halos about normal galaxies such as our own and M31 may be transient phenomena that were produced as the result of a violent outburst in the nuclear region of a galaxy. The time scale to be associated with such a halo lies in the range $5 \times 10^7$–$10^9$ years, depending on the conditions that are developed in the gas following the outburst. On this picture the explosion of the center was also responsible for the outward-moving gas that is seen in the disk of our galaxy, and it appears from this that the outburst took place about $10^7$ years ago. The high-energy particles that fill such a halo may have come from the intergalactic medium, or they too may have been produced in the outburst. Violent events of this type may be recurrent in some galaxies. (auth)

**32849** THE EVOLUTION OF THE CENTRAL STARS OF PLANETARY NEBULAE. C. R. O'Dell (Carnegie Institution of Washington, Washington, D. C. and California Inst. of Tech., Pasadena). Astrophys. J., 138: 67-78 (July 1, 1963).

A new temperature scale for the planetary nebulae is derived based upon the Hβ recombination line of ionized hydrogen of the nebular shell and the photographic magnitude of the central star. The temperatures are systematically larger than those derived by Berman. The mean sizes of the nebular shells are used to indicate the time scale of the changes occurring in the central stars. The stars are seen to be in a rapidly contracting state with the radius shrinking from over 1 solar radius to one-one hundredth of the solar radius in a time scale of 25000 years, while the effective temperature rises from 40,000 to 150,000°K, thereby entering regions of almost complete degeneracy. It is shown that these star + nebula systems represent the gravitational-collapse phase of evolution of stars of about 1.2 solar masses as their nuclear fuel-burning is completed. The stars, having passed through the state having planetary nebulae, can account for a large fraction of the presently observed white dwarfs. (auth)

**32850** THE INFLUENCE OF NEUTRINO PROCESSES ON LATE STAGES OF STELLAR EVOLUTION. Hubert Reeves (Univ. of Montreal and Inst. for Space Studies, New York). Astrophys. J., 138: 79-89(July 1, 1963).

It is assumed that neutrino processes from a direct coupling between electrons and neutrinos do occur in reality. Using a crude model, it is shown that these processes have a marked effect on the characteristics of the late stages of stability of stellar evolution. These stages occur at higher temperature, pour out more power, and last shorter periods than would be the case if these processes were absent. Estimates are given. This analysis, together with more accurate calculations, could eventually be used to prove or disprove the existence of such neutrino processes. (auth)

**32851** THE ULTRAVIOLET SPECTRUM OF 3 CENTAURI A. Jun Jugaku and Wallace L. W. Sargent (Carnegie Institution of Washington, Washington, D. C. and California Inst. of Tech., Pasadena). Astrophys. J., 138: 90-6(July 1, 1963).

A list of identifications is given for 65 lines measured on a Radcliffe coudé spectrogram of the region λλ 3120-3700 in the spectrum of 3 Cen A (B4p). Lines of Mn II are present; the resonance Be II doublet λ 3130 is absent. Relative abundances or upper limits for Be and the iron-peak elements are derived by comparison with α Lyr (A0 V).

The abundance ratio Mn : Fe is normal in 3 Cen A; that of Ni : Fe is a little low; the abundance of Be is less than, or equal to, that in $\alpha$ Lyr, while the abundance ratio Cr : Fe is lower than in 3 Cen A than in $\alpha$ Lyr by a factor of more than about 40. The possible relation between 3 Cen A and the magnetic peculiar A stars is discussed in the light of these new results. (auth)

**32852** METAL ABUNDANCES IN THE SUBGIANT $\zeta$ HERCULIS AND THREE OTHER dG STARS. H. L. Helfer (Univ. of Rochester, N. Y.), G. Wallerstein, and J. L. Greenstein. Astrophys. J., 138: 97-117(July 1, 1963).

Abundances for 32 elements are obtained for the G stars $\zeta$ Her, 99 Her, $\beta$ Com, and 85 Peg. $\zeta$ Her, a high-velocity subgiant with well-determined mass, possesses solar metal abundance; the previously reported metal deficiency of 85 Peg and 99 Her and the normal metal content of $\beta$ Com are substantiated. A search for representative unblended lines of 18 additional elements yielded little additional information, only that these elements were not strongly overabundant. The relative excess of $\alpha$-elements in 85 Peg is confirmed, sulfur now being added to the list of observable $\alpha$-elements. The manganese deficiency in the metal-poor stars is well established. Abundances of many elements of atomic weight heavier than the iron group of elements were obtained; generally their abundance relative to iron is about the same as in the sun. In both metal-deficient stars, samarium appears overabundant, and there is a possibility that molybdenum and ruthenium may be overabundant in 85 Peg. (auth)

**32853** A PREFACE TO COSMOGONY. I. THE ENERGY EQUATION AND THE VIRIAL THEOREM FOR COSMIC DISTRIBUTIONS. David Layzer (Harvard Univ., Cambridge, Mass.). Astrophys. J., 138: 174-84(July 1, 1963).

The dynamics of an unbounded, statistically homogeneous, and isotropic distribution of gravitating particles are considered. As is well known, the mean density and velocity fields depend on a single function, the cosmic scale factor R(t), given by relativistic cosmology. In an approximation that is adequate for all astronomical applications, the peculiar velocity v of a test particle is shown to satisfy the equations of motion. In a uniform medium ($\sigma \equiv 0$) the velocity of a test particle decays as $R^{-1}$. More generally, the form of the equations of motion implies that initial conditions cannot have an enduring influence on particle motions, which must accordingly be caused mainly by the action of the fluctuating gravitational force field. This idea finds its mathematical expression in two coupled equations for $T_m = \frac{1}{2}\langle v^2 \rangle_m$, the mean peculiar kinetic energy per unit mass, and $U_m = \frac{1}{2}\langle \varphi \rangle_m$, the mean peculiar potential energy per unit mass. The cosmologic energy equation was first obtained by Irvine. The second equation (the cosmologic virial theorem) is here derived by a fundamentally different method from the one used to derive the virial theorem for a bounded system. The present method applies also to bounded systems, but the conventional method breaks down when applied to an unbounded system. The cosmologic virial theorem is expected to be valid as long as non-gravitational forces and the effects of radiation are negligible. The specific energies $T_m$ and $U_m$ are then nearly constant in time. The constancy of $U_m$ is a measure of the density contrast, implies that $\alpha^2$ increases at least as fast as R—a conclusion reached previously by a less rigorous argument. (auth)

**32854** A KINEMATICAL THEORY OF TURBULENT HYDROMAGNETIC FIELDS. E. N. Parker (Univ. of Chicago and Univ. of Colorado, Boulder). Astrophys. J., 138: 226-38(July 1, 1963).

A kinematical theory is developed for the rms magnetic fields produced by the interaction of turbulent eddies, of scale a and velocity v, with a large-scale weak magnetic field $B_0$. The principal interest lies in the small-scale magnetic field generated by the observed photospheric granules in the observed large-scale photospheric magnetic fields. The theory considers how a rope of magnetic flux is both lengthened and widened by the velocity gradients in statistically stationary, isotropic, homogeneous turbulence in which the velocity fields are given. Both the amplification and diffusion of the magnetic field are then computed from the proportions of the rope of flux, employing the usual statistical assumption that moments of order 2n can be expressed in terms of the product of n factors of second moments. The conclusion is that a weak field $B_0$ can be amplified by a factor of the order of $R^{\frac{1}{2}}/\ln R$, where R is the magnetic Reynolds number. In the solar photospheric granules this amounts to amplification by a factor less than 10, so that the small-scale rms fields resulting in quiet regions where $B_0 \cong 1$ gauss are far below the value for equipartition of energy with the velocity field. (auth)

**32855** SPECTRAL OBSERVATIONS OF SOLAR RADIO BURSTS. IV. THE EXCITERS OF FAST-DRIFT BURSTS. M. P. Hughes and R. L. Harkness (Harvard Coll. Observatory, Fort Davis, Tex.). Astrophys. J., 138: 239-51(July 1, 1963).

An analysis of a sample of fast-drift bursts (spectral type III) are presented. The bursts are assumed to be the result of radiation from plasma oscillations in the sun's corona, where the temperature is assumed to be $10^6$K and the electron density distribution that given by the Baumbach-Allen formula increased by a factor of 10. The frequency drift of the bursts is interpreted in terms of an outward-moving disturbance having a radial component of velocity of about 0.4 c. In the case of such high exciter velocities, a correction must be made for the finite velocity of the radiation. Differential group delay, however, causes only a small error in the derived velocities. The duration and band width of the bursts at different frequencies are used to obtain estimates of the dispersion of the exciters at different heights in the corona. A small sample of fundamental-harmonic pairs is analyzed to determine the effects of the undetected presence of harmonics or the absence of fundamentals. In conclusion, some of the proposed mechanisms that may account for the bursts are reviewed. (auth)

**32856** OBSERVATIONAL STUDY OF MACROSCOPIC INHOMOGENEITIES IN THE SOLAR ATMOSPHERE. IV. VELOCITY AND INTENSITY FLUCTUATIONS OBSERVED IN THE K LINE. Eberhart Jensen and Frank Q. Orrall (Sacramento Peak Observatory, Sunspot, N. Mex.). Astrophys. J., 138: 252-70(July 1, 1963).

A photometric study was made of a series of 51 high-dispersion spectrograms separated in time by 30 seconds, obtained at the center of the sun's disk, in the region $\lambda\lambda$ 3928–3940. Intensity, as measured at five wavelengths in $K_1$, $K_2$, and $K_3$, and vertical velocity, as implied by displacements of the two Fe I lines, $\lambda$ 3931.122 and $\lambda$ 3937.329, were obtained at all 51 times of observation as a function of position on the sun. These measurements were used to construct curves of velocity as a function of time for 92 places on the sun and intensity as a function of time at five wavelengths for 33 positions on the sun. Profiles of the center of the K line were obtained for 76 positions on the sun at one time and for two positions on the sun at 51 times.

The two Fe I lines show the quasi-periodic vertical velocity fluctuations found in other Fraunhofer lines. The average period obtained for well-defined oscillations was 273 seconds and the rms velocity as averaged across the sun was 0.203 km/sec. The intensity in $K_1$ (±0.55 A from the line center) varied with position on the sun, corresponding to the mottles and coarse network seen on spectroheliograms. The rms fluctuation as averaged over the observed portion of the sun was 0.0685. The intensity in $K_1$ varied quasi-periodically in time, and these variations were correlated with the variations in velocity as observed in the Fe I lines, but out of phase, in the sense that the maximum in $K_1$ intensity occurred one-quarter period before the maximum upward velocity. The average rms fluctuation with time was 0.0342. In the wings of the K line, the intensity showed the same variation in time at 0.55, 1.16, 1.84, and 2.21 A from the line center. If there was any phase difference, it was less than 30 seconds. The intensity at $K_3$ and $K_2$ and the asymmetry of the $K_2$ peaks all varied with time. An autocorrelation analysis of a typical region at the center of the disk confirmed that the intensity fluctuations in $K_1$, $K_2$, and $K_3$ were periodic. For $K_1$ and $K_2$ the period was 250 seconds and for $K_3$, 170 seconds. There is no obvious difference between the time fluctuations of intensity and velocity in the bright and dark features, although this remains to be tested by a refined analysis. The red $K_2$ peak was greater than the violet on 25 per cent of the sun covered by our observations. The $K_2$ peaks are missing at 12 of the 76 places on the sun where the line profile was measured. A brief discussion of the nature of these oscillations is given. It is pointed out that only about 1 per cent of the estimated flux of non-thermal energy from the convection zone is required to maintain them. The observed periods are in the range of standing sonic waves, and the phase difference between velocity and intensity corresponds to adiabatic conditions. The phase difference is not consistent with adiabatic running sonic waves. It is suggested that the fluctuations may be due in part to simple isobaric oscillations associated with the static stability of the atmosphere above the convective zone. (auth)

**32857** SIMILAR IONOSPHERIC RESPONSES OF SOME RECURRING FLARES. Teresa Fortini (High Altitude Observatory, Boulder, Colo.). Astrophys. J., 138: 278-80 (July 1, 1963).

Sudden enhancements of atmospherics (SEA) and, even more, sudden cosmic-noise absorptions (SCNA) due to flares recurring in the same area of an active region seem to follow similar trends of development, exhibited in eight groups of events occurring in 1958. If flare x radiation occurs during simple heating and relaxation of solar gases, its developmental character should be similar from flare to flare, even in different regions. However, flare x-ray development as manifested by SCNA's and SEA's is as characteristic of individual flaring regions as the flares themselves. A thermal model in which gases rapidly heat and then cool does not seem capable of explaining these variations. The conclusion is reached that the x radiation represents the immediate response of the solar atmosphere to the presence of high-energy particles. Patterns of fine development may then recur as a result of the influences of persistent magnetic fields that control the particle motions. (auth)

**32858** NOTE ON TOTAL ENERGY OF WHITE DWARF MODELS. M. Savedoff (Univ. of Rochester, N. Y.). Astrophys. J., 138: 291-3(July 1, 1963).

The total energy of completely degenerate white dwarf models was tabulated. From the data it is estimated that the total energy available from gravitational collapse is less than 3 per cent of that available from converting the same mass of hydrogen to iron. The results apply to models in which nuclear and general relativistic effects are not dominant. (C.E.S.)

**32859** THE SOLAR-FLARE PHENOMENON AND THE THEORY OF RECONNECTION AND ANNIHILATION OF MAGNETIC FIELDS. E. N. Parker (National Center for Atmospheric Research, Boulder, Colo. and Univ. of Chicago). Astrophys. J., 138: 310-11(July 1, 1963).

A study of contemporary theory and observation of the solar-flare phenomenon is presented for the purpose of forming some judgment of the popular notion that the solar flare is explained by the annihilation of magnetic fields in the site of the visible flare. The discussion deals principally with the basic energy consideration. The energy output of a class 3 or 3+ solar flare is estimated to be $2 \times 10^{32}$ ergs. It is concluded that there is at present no idea of how a magnetic field might be annihilated sufficiently rapidly in a solar flare to account for the energy release that seems to occur. Directions for future explorations are discussed. (C.E.S.)

**32860** SATELLITE MEASUREMENTS IN THE "STARFISH" ARTIFICIAL RADIATION ZONE. I. B. McDiarmid, J. R. Burrows, E. E. Budzinski, and D. C. Rose (National Research Council, Ottawa). Can. J. Phys., 41: 1332-45 (Aug. 1963). (NRC-7452)

Particle detectors in the Alouette satellite have been used to study radiation artificially injected into the earth's magnetic field by the "Starfish" high-altitude nuclear explosion. The spatial distribution of electrons with energies greater than 3.9 Mev is given for a time about three months after the explosion for regions in BL space sampled by the satellite. The measurements show that the electron spectrum is a strong function of the magnetic shell parameter L; in the range L = 1.25 to 1.70 there is a marked softening of the spectrum with increasing L. The decay of the artificial radiation zone has been studied for a period of from three to six months following the explosion, and decay constants at different points in BL space have been estimated. (auth)

**32861** AURORAL PATCHES SHOWING STRONG HYDROGEN LINES. L. E. Montbriand and A. Vallance Jones (Univ. of Saskatchewan, Saskatoon). Can. J. Phys., 41: 1393-5(Aug. 1963).

Observations with an all-sky camera and high-speed patrol spectrograph of a peculiar auroral cloud or patch from Saskatoon on the night of April 26/27, 1960, are reported. Interpretations of this phenomenon are given. (L.T.W.)

**32862** A STUDY OF THE OUTER GEOMAGNETIC FIELD. Laurence J. Cahill, Jr. (National Aeronautics and Space Administration, Washington, D. C.). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 10-19(July 1963).

The boundary between the geomagnetic field and the interplanetary media was found to be located at approximately 10 Re on the sunlit side of the earth near the equator. It was observed to fluctuate between 8 and 14 Re. A region of turbulent magnetic fields exists between the geomagnetic field boundary near 10 Re and another boundary located at 14–15 Re near the earth-sun line. The geomagnetic field inside the boundary is relatively quiet. An abrupt transition in the magnitude of fluctuation occurs at the boundary surface. The ring current location appears to be above 1.4 and below 5 Re. Variation in altitude of the

ring current with time appears likely. A brief review of the magnetometer instruments used is also given. (C.E.S.)

**32863** GUIDING-CENTER APPROXIMATION IN THE DIAMAGNETIC RING CURRENT. Mieczysław F. Kozłowskii (Univ. of Warsaw). J. Geophys. Res., 68: 4421-8 (Aug. 1, 1963).

The guiding-center approximation for protons in the diamagnetic ring current is valid when two known conditions are satisfied. The critical energies, magnetic rigidities, and pitch angles in the geomagnetic field and the field of the ring current are studied, and the results are applied, as an example, to a model proposed ring-current belt. It is found that protons with energies 20 to 40 kev are most likely to be responsible for the belt. The lifetime of these protons in the ring current belt is estimated at 10 days, as observed on the magnetograms. The pp pulsations may, as it seems, be the cause of magnetic scattering of the ring current. This is suggested on the basis of the coincidence of commencements of pp pulsations and the quicker increase of the H force during the main phase at equatorial magnetic stations. (auth)

**32864** DEFORMATION OF MAGNETIC SHELLS DURING MAGNETIC STORMS. S.-I. Akasofu (Univ. of Alaska, College). J. Geophys. Res., 68: 4437-45(Aug. 1, 1963).

The nature of the distortion of the earth's magnetic field in the radiation belt regions is examined for the combination of two external sources of distortion, the ring current and the solar plasma flow. The distortion is expressed by diagrams showing the location of two points on the distorted lines of force, the radial distance $r_e$ of a point at which the line of force crosses the equator and its anchoring latitude $\phi$ (or $L = 1/\cos^2 \phi$) on the earth's surface. The $r_e - \phi$ (or $r_e - L$) diagrams thus constructed are of use in a study of the deformations of the outer radiation belt. It is suggested that the lowering of the boundary L value of the outer belt, observed by the Injun 1 satellite during magnetic storms, is caused by the growth of the ring current embedded within the outer belt. (auth)

**32865** NEGATIVE CORRELATION BETWEEN POLAR-CAP VISUAL AURORA AND MAGNETIC ACTIVITY. T. N. Davis (Univ. of Alaska, College). J. Geophys. Res., 68: 4447-53(Aug. 1, 1963).

The relationship between the local (K) and planetary ($K_p$) magnetic activity and the occurrence of visual auroras inside the auroral zone is investigated. The visual aurora above geomagnetic latitude 80° is found to be negatively correlated with the K and $K_p$ magnetic indexes, whereas nearer to the auroral zone the correlation is positive. The relationship in the region 75 to 80° latitude is more complicated and has a transitional nature. (auth)

**32866** HELIUM 3 IN PLANETESIMALS. Henri E. Mitler (Harvard Univ., Cambridge, Mass.). J. Geophys. Res., 68: 4587-94(Aug. 1, 1963).

With a homogeneous sphere of icy silicate—a suggested protoplanetary model—the production and concentration of $He^3$ resulting from bombardment by prehistoric solar protons are calculated as a function of time and sphere radius. The protons spallate isotopes of Li, Be, and B in a "skin" about the sphere. It is shown that the present terrestrially observed isotopic ratios can be obtained consistently only if the $He^3$ concentration in the skin never rose above 6600 per $10^6$ silicon atoms. The maximum found is about 500, so that $He^3$ production is not a problem with this model. Assumptions are described that are made for the average energy of protons, duration of bombardment, composition of the sphere, and its mean blackbody temperature. (auth)

**32867** GEOMAGNETICALLY CONJUGATE RELATIONSHIPS OF GIANT PULSATIONS AT SYOWA BASE, ANTARCTICA, AND REYKJAVIK, ICELAND. Takesi Nagata, S. Kokubun, and T. Iijima (Tokyo Univ.). J. Geophys. Res., 68: 4621-5(Aug. 1, 1963).

The Antarctic and Iceland stations are within 52 km of being magnetically conjugate. The geomagnetic force line passing through these stations crosses the geomagnetic equator at about 4.95 earth radii above the earth's surface. Geomagnetic dampened waves having amplitudes up to several hundred gamma and periods of several minutes are observed at these stations. As examples, magnetogram records of these waves taken at the same time at the conjugate stations are compared, as are records of the loci of the polarization vectors of the waves. The correlations between these simultaneous observations are described and analyzed. (T.F.H.)

**32868** AN EXPLANATION OF TRIGGERED VERY-LOW-FREQUENCY EMISSIONS. Neil Brice (Stanford Univ., Calif.). J. Geophys. Res., 68: 4626-8(Aug. 1, 1963).

A mechanism is proposed for the generation of vlf waves in the earth's vicinity. It is assumed that the waves are produced by resonance interactions between waves propagating in a plasma and energetic charged particles trapped in the geomagnetic field. It is postulated that the high intensities of vlf radiation that are observed, as contrasted with intensities expected from the low radiation yield of the resonance interaction and a reasonable particle density, require the existence of coherence in the radiation. This coherent radiation is proposed to be produced by organization of the relative phases of the helical orbits of the geomagnetically trapped particles. The mechanism proposed makes use of the cyclotron resonance between the plasma waves and the particles. (T.F.H.)

**32869** ABUNDANCES OF ISOTOPES SYNTHESIZED BY A FAST-NEUTRON CAPTURE PROCESS ($70 \leq A \leq 110$). M. P. Lacroute (Observatoire de Strasbourg) and M. M. Timores. J. Phys., 24: 273-8(Apr. 1963). (In French)

The r process of the synthesis of the elements in stars is examined. A method of calculation taking into account the cross sections of reactions $(n,\gamma)$ for nuclei lying out of the valley of stability is set up, in order to find the abundances of nuclei produced by exposure of "seed" nuclei, such as $Fe^{56}$, to a high neutron flux in permanent action that is suddenly cut off ("steady-flow"). This method of calculation considers the possible ramifications in the path of the r process. The obtained results are satisfactory, especially if the fact is kept in mind that the reactions $(\gamma,n)$ are ignored for the take of simplification. The value of the neutron density is $10^{20}$ neutron $\cdot$ $cm^{-3}$ at a temperature of $10^9$ degrees. In the area where the reactions take place, the remaining iron is present in a very low proportion; this implies that the process could occur only in very limited regions of space. Moreover, the hypothesis of "steady-flow" is certainly not right, and more advanced calculations should be carried out. (auth)

**32870** EFFECTS OF TEMPERATURE CHANGES ON THE ELECTRON DENSITY PROFILE IN THE F2 LAYER. O. K. Garriott (Stanford Univ., Calif.) and H. Rishbeth. Planetary Space Sci., 11: 587-90(June 1963).

The effects of a thermal expansion of the atmosphere on the neutral composition and on the electron density in the ionosphere are considered. The ionosphere is assumed to be in equilibrium; the production, loss, and diffusion of

ionization are considered and their dependence on temperature T is discussed. It is concluded that at a fixed pressure level the relative concentration of each neutral constituent of the atmosphere is unchanged with changes in temperature and, within certain assumptions, the electron density is proportional to $T^{-\frac{1}{2}}$. The variation of total electron content is then proportional to $T^{+\frac{1}{2}}$. (auth)

**32871** SOLAR FLARES AND ASSOCIATED PHENOMENA. M. A. Ellison (Dublin Inst. for Advanced Studies). Planetary Space Sci., 11: 597-619(June 1963).

A review is made of some of the more important papers on solar flares and their associated effects that were contributed since the beginning of the I.G.Y. (auth)

**32872** IONOSPHERIC DRIFTS AND E-REGION IRREGULARITIES. J. H. Piddington (CSIRO, Sydney). Planetary Space Sci., 11: 639-53(June 1963).

A physical interpretation is attempted for the components of electrodynamic drift of ionization in a lightly ionized gas. Only one component, representing the flux of neutral ionization appears capable of leading to the formation of irregularities in the electron density. A satisfactory theory of equatorial sporadic E must depend directly on the upward drift of ionization associated with the $S_q$ dynamo. Two possible effects are discussed: an upward positive gradient of neutral atoms, caused by air turbulence and an irregular distribution of negative heavy ions. In each case strong convergence of electrons may result. A theory of auroral-zone sporadic E is briefly restated. It depends on the DS dynamo that includes large scale shear motions in the magnetosphere, driven by the solar wind. These shear motions give rise to divergent electric fields in the ionosphere that cause convergence of neutral ionization in the E-region. These in turn react on the magnetosphere to cause ion precipitation that adds a further contribution to sporadic E. Data for temperate-zone sporadic E strongly favor local winds. The presence of wind shear may not be necessary. The theory of turbulence suggests that the largest wind cells should provide the highest wind speeds and so the largest dynamo fields and drift velocities. Such large cells would tend to be free of shear throughout E-region. They may cause convergence of ionization at various levels according to wind direction. A possible connection between $E_s$ and thunderstorms may be explained in terms of winds extending into the E-region. (auth)

**32873** FLUORESCENCE OF SOLAR IONIZING RADIATION. A. Dalgarno (Geophysics Corp. of America, Bedford, Mass.) and M. B. McElroy. Planetary Space Sci., 11: 727-8(June 1963).

An examination of the spectral features arising from fluorescence of solar ionizing radiation based on model atmospheres, solar fluxes, and absorption cross sections is presented. The most intense features are the first negative and Meinel band systems of $N_2^+$, each of which has a predicted intensity at noon of about 10 kilorayleighs. (C.E.S.)

**32874** THE MAGNETO-HYDRODYNAMICS OF A ROTATING FLUID AND THE EARTH'S DYNAMO PROBLEM. J. B. Taylor (United Kingdom Atomic Energy Authority, Abingdon, Berks, Eng.). Proc. Roy. Soc. (London), Ser. A, 274: 274-83(July 23, 1963).

A rotating, incompressible fluid enclosed within a rigid boundary that is a surface of revolution is discussed. It is shown that if viscous forces are negligible, then, in the presence of magnetic fields, the fluid can execute slow, steady relative motions only if the magnetic force satisfies a constraint. In cylindrical polar co-ordinates this constraint can be written $\int_{r=s} (j \times B)_\phi \, d\phi \, dz = 0$; that is, the couple exerted by the magnetic forces on any cylinder of fluid coaxial with the axis of rotation must vanish. Furthermore, subject to certain restrictions on the shape of the container, it is shown that if the field satisfies the above condition then the fluid velocity is completely determined by the instantaneous value of the magnetic field. This velocity is such that the necessary conditions on the field will continue to be satisfied. An algorithm for the determination of the velocity is given and its application to the earth's dynamo problem is indicated. (auth)

**32875** PHOTOMETRY OF LARGE SOLAR FLARES. Ho-chi Chang and Chiao-Shiu Hao (Purple Mountain Observatory, Nanking, China). Sci. Sinica (Peking), 12: 965-77(July 1963). (In English)

Results of photometric and positional measurements of bright spots in three large solar flares are given. It is shown that these bright spots, being not stationary, move with velocities in the range of 10–20 km/sec for III and III + flares. (auth)

**32876** THE MAGNETOPAUSE: A NEW FRONTIER IN SPACE. C. O. Hines (Univ. of Chicago). Science, 141: 130-6(July 12, 1963).

The magnetopause is defined as the frontier between the terrestrial and the solar atmospheres. The nature of the magnetopause and the processes it influences are discussed. (P.C.H.)

**32877** TYPE IV SOLAR RADIO EMISSION. A. D. Fokker (Sterrewacht Sonnenborgh, Utrecht). Space Sci. Rev., 2: 70-90(July 1963). (In English)

The spectral type IV solar radio emission event is defined, and its appearance in the centimetric, metric, and decimetric wavelengths is described. In order to distinguish various components of type IV emission, the height and angular diameter of the source as well as polarization and directivity of the radiation are considered. The optical solar phenomena associated with type IV emission are also described. The occurrence of type IV events throughout the solar cycle and the physical picture of the event are discussed. (C.E.S.)

**32878** THE MAIN PHASE OF MAGNETIC STORMS AND THE RING CURRENT. Syun-Ichi Akasofu (Univ. of Alaska, College). Space Sci. Rev., 2: 91-135(July 1963). (In English)

The ring current, a westward electric current encircling the earth which is responsible for the main phase decrease of magnetic storms, is discussed. Present knowledge of the ring current is summarized, and several important problems that must be explored further are discussed. The motion of charged particles in a dipole field, the electric current resulting from this motion, and the magnetic fields produced by the ring current are considered. The magnetic moment of the ring current, its deformation effects on the outer radiation belt, and its growth time are also discussed. (C.E.S.)

**32879** MAGNETIC FIELD OF THE EARTH AND PLANETS. J. W. Kern and E. H. Vestine (RAND Corp., Santa Monica, Calif.). Space Sci. Rev., 2: 136-71(July 1963). (In English)

Knowledge of geomagnetism and its effects was recently much augmented during the IGY; when added to what is known of stellar fields, interplanetary fields, and meteoric magnetism, and combined with magnetic theory, this knowledge not only suggests that much may be learned of our neighbors in space by making an early determination of their magnetic fields, but also provides a foundation for

many inferences and rough estimates on the magnetic fields of other solar-system bodies. Present estimates range from 660 cgs for Jupiter to 0.004 for the smaller satellites and the planetoids. (auth)

**32880** SUPERNOVAE, NEUTRON STARS, AND TWO KINDS OF NEUTRINO. H. Y. Chiu (Inst. for Space Studies, New York and Columbia Univ., New York). 15p. (CONF-63-2)

From American Physical Society Meeting, Seattle, Aug. 1962.

The role of neutrinos in the core of a star that has undergone a supernova explosion is discussed. The existence of neutron stars, the Schwarzchild singularity in general relativity, and the meaning of conservation of baryons in the neighborhood of a Schwarzchild singularity are also considered. The problem of detection of neutron stars is discussed. It is concluded that neutron stars are the most plausible alternative for the remnant of the core of a supernova. The neutrino emission processes are divided into two groups: the neutrino associated with the meson ($\mu$) and the production of electron neutrinos. (C.E.S.)

**32881** INTERACTION OF COSMIC AND SOLAR FLARE RADIATIONS WITH THE MARTIAN ATMOSPHERE AND THEIR BIOLOGICAL IMPLICATIONS. Herman Yagoda (Air Force Cambridge Research Labs., Bedford, Mass.). 3p. (CONF-85-2)

From American Meteorological Society Meeting, Washington, D. C., Apr. 1963.

A study of neutron production in the Martian atmosphere was made based on the assumptions that the flux of charged cosmic and solar flare radiation primaries as measured above the earth's atmosphere is typical of the interplanetary flux, that the nuclear interaction parameters for the Martian atmosphere (largely nitrogen and argon) are of the same magnitude as measured in terrestrial air, and that Mars does not have any appreciable magnetic field. These calculations indicate the production of 1.56 neutrons $cm^{-2}$ $sec^{-1}$ if the Martian air mass is 227 g $cm^{-2}$ and the value can be as small as 0.7 on the basis of Schilling's lower limit. (auth)

**32882** THE CALCULATION OF ELECTRON ENERGY DISTRIBUTION FUNCTIONS IN THE IONOSPHERE. L. R. Megill (National Bureau of Standards, Boulder, Colo.) and J. H. Cahn. 25p. (CONF-71-1).

From Gaseous Electronics Conference, Boulder, Colo., Oct. 1962.

The necessary equations for calculating electron energy distribution functions in the ionosphere are formulated. The formulation includes the effects of elastic collisions of the electrons with the background gas, inelastic collisions, and the mutual electron interactions. It is shown that the distribution function is Maxwellian when the ratio of electron density $N_e$ to neutral density N is such that $(N_e/N) > (2m/M)\,(\sigma_{el}/10^{-14})\,\mu^2$ and $(N_e/N) > (\sigma_{inel}/10^{-14})\,\mu^2$ where $\mu$ is energy in ev, $\sigma_{el}$ and $\sigma_{inel}$ are the elastic and inelastic cross sections respectively in units of $cm^2$. Examples are shown to demonstrate that above 220 km the distribution function shapes are dominated by electron interactions. (auth)

**32883** NEUTRON CAPTURE AND STELLAR NUCLEOSYNTHESIS. J. H. Gibbons. 7p. (CONF-46-24)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

Elements in the universe are thought to have been synthesized by neutron capture in stellar interiors. Neutron cross section data supporting synthesis of the abundant isotopes of heavy elements by a long time-scale capture process are reviewed. (D.C.W.)

## Cosmic Radiation

**32884** (AEDC-TDR-63-118) THE SIMULATION OF HIGH ENERGY PENETRATING RADIATIONS. George MacFarlane (Arnold Engineering Development Center, Arnold AF Station, Tenn.). May 1963. Contract AF40 (600)-1000. 69p. (AD-409747)

A search was made of current literature to determine the penetrating radiation characteristics of the space environments and to assess the necessity for reproducing such environments completely or in part. This study of the radiation environments led to the formulation of some possible test objectives. The advantages and disadvantages of performing these objectives in the proposed chamber are listed. Two main simulation approaches, one using radiation from isotopic sources and the other using particles generated by high energy accelerators, are feasible. But taking into account the size of the vehicles to be tested, and the fact that the second method only can provide a worthwhile match of the energy and flux spectra of space radiation, only this method was considered. (auth)

**32885** RECENT STUDIES OF SOLAR COSMIC RAYS. C. J. Waddington (Univ. of Minnesota, Minneapolis). IEEE (Inst. Elec. Electron. Engrs.), Trans. Nucl. Sci., NS-10: No. 3, 1-9(July 1963).

The energetic protons and heavier nuclei accelerated in solar flares were measured during many events by detectors on balloons and space vehicles. These particles are distributed according to exponential spectra expressed in terms of their magnetic rigidity. This spectral form permits an understanding of several of the associated phenomena that also occur during these events. A study of the time variations of the intensities near the earth show that these variations can be explained by a diffusion model. The adjustable parameters specifying this process, the mean-free-path, and the dimensions of the diffusing medium, may be determined from these studies. (auth)

**32886** THE ENERGY SPECTRUM OF GALACTIC ELECTRONS PRODUCED BY COSMIC RAYS. Frank C. Jones (Princeton Univ., N. J.). J. Geophys. Res., 68: 4399-4407(Aug. 1, 1963).

Collisions between cosmic protons and interstellar hydrogen nuclei will produce secondary electrons through the reaction chain $p + p \rightarrow N + N + k\pi$; $\pi^{\pm} \rightarrow \mu^{\pm} + \nu$; and $\mu^{\pm} \rightarrow e^{\pm} + 2\nu$. The production energy spectrum of these electrons is calculated by means of a simplified version of the isobaric nucleon model of pion production. The resulting spectrum exhibits a broad maximum at a kinetic energy of about 25 Mev. It is shown that the high-energy (E > 1 Bev) part of the spectrum is of the same form as the cosmic-ray spectrum if the total inelastic p-p cross section remains essentially constant at high energies. (auth)

**32887** ON PRODUCTION OF TRITIUM IN THE ATMOSPHERE. V. Lujanas (V. Luyanas) (Inst. of Geology and Geography, Academy of Sciences, Lithuanian SSR). Lietuvos TSR Mokslu Akad. Darbai, Ser. B, 1(32): 21-8 (1963). (In Russian)

Tritium production in the atmosphere by cosmic rays was calculated with evaporation neutron spectra, $N(E)dE = kEe^{-E}dE$, and fast neutron spectra, $N(E)dE = zE^{-c}e^{-1/E-1}dE$, the mean tritium production is 0.12 atoms per $cm^2$/sec. Production of $H^3$ in stars is 0.24 atoms per $cm^2$/sec. The possibility of tritium production by inner radiation belt protons is also discussed. (tr-auth)

**32888** ON THE NUCLEAR EMULSION BACKGROUND IN STUDIES OF $\alpha$ RADIOACTIVITY IN ATMOSPHERE. V. Pocius (V. Yu. Potsiyus) and J. Tomkus (I. S. Tomkus) (Inst. of Geology and Geography, Academy of Sciences, Lithuanian SSR). Lietuvos TSR Mokslu Akad. Darbai, Ser. B., 1(32): 29-32(1963). (In Russian)

It was found that the number of $\alpha$ tracks in 50-$\mu$ A-2 nuclear emulsion increases about 10 tracks/cm$^2$ per day; 0.5 tracks/cm$^2$ per day in the upper ten $\mu$. Measurements of the track lengths in the upper emulsion layer indicate the largest number (45.8%) of tracks are from 20 to 30 $\mu$. A 5 minute soaking of the emulsion in a 0.1% solution of red potassium ferricyanide produces the most efficient background picture. (tr-auth)

**32889** LOSS OF VAN ALLEN ELECTRONS DUE TO WHISTLERS. J. W. Dungey (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). Planetary Space Sci., 11: 591-5(June 1963).

The change in pitch angle due to resonance with a whistler is estimated for 1-Mev electrons. The effect is found to be important between the inner and outer belts. The resonant frequency varies rapidly with the magnetic shell and is high for the inner belt. The fall in the spectrum of whistlers above 20 kc may account for the rapid change of lifetime with shell beyond the inner belt. An estimate is made of the power required for a man-made transmitter to have a significant effect in the inner belt. (auth)

**32890** THE DISTRIBUTION OF ENERGY IN THE ELECTRON-PHOTON COMPONENT OF EXTENSIVE AIR SHOWERS. S. C. Lillicrap (Imperial Coll. of Science and Tech., London), R. D. Wills, and K. E. Turver. Proc. Phys. Soc. (London), 82: 95-106(July 1963).

An array of four water Cherenkov detectors of variable depth was used to study extensive air showers of size $10^5$ to $10^6$ particles. The amount of Cherenkov light produced is a measure of the total electron track length in the detectors resulting from the incident spectrum of electrons and photons. The difference between the lateral structure function as measured by the Cherenkov detectors and the known particle density distribution function is therefore related to the presence of cascading or attenuation in the water. This was confirmed by observations with Geiger counters above and below a detector. These effects in the water are thus a measure of the energy of the electron-photon component. The energy carried by this component per shower electron was found to vary between 440 ± 60 Mev at a distance of 2 m from the shower axis and 195 ± 35 Mev at 12 m distance. The part of this energy that is carried by photons was found to be greater than that carried by electrons throughout most of the region examined. (auth)

**32891** THE FLUX OF PRIMARY COSMIC RAY $\alpha$ PARTICLES. C. Dahanayake, P. C. B. Fernando, and M. L. T. Kannangara (Univ. of Ceylon, Colombo). Proc. Phys. Soc. (London), 82: 107-9(July 1963).

A determination of the primary cosmic ray $\alpha$-particle flux, at Minnesota on 30th July 1957 is reported. The total flux is estimated to be 164 ± 17 particles m$^{-2}$ sterad$^{-1}$ sec$^{-1}$. (auth)

**32892** NUCLEAR-ACTIVE PARTICLE SPECTRUM AT 3260 METERS ABOVE SEA LEVEL. N. L. Grigorov, I. N. Erofeeva, V. S. Murzin, L. G. Mishchenko, I. D. Rapoport, B. O. Rostomyan, V. A. Sobinyakov, and A. F. Titenkov (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 44: 1806-10(June 1963). (In Russian)

The energy spectrum of nuclear-active particles at 3260 m above sea level was studied with an ionization calorimeter. For energies between $2.10^{11}$ an $2.10^{12}$ ev the integral energy spectrum could be represented by a power law with exponent $\gamma = 1.92$, a statistical error of 5 to 7%, and methodological uncertainty of 0.05. (auth)

**32893** INTERACTIONS OF HEAVY NUCLEI WITH ENERGY > $10^{12}$ ev/NUCLEON. R. W. Huggett (Louisiana State Univ., Baton Rouge), R. L. Fricken, F. Abraham, J. Kidd, R. Levi Setti, C. H. Tsao, and W. Wolter. 5p. (CONF-46-21)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

Nuclear interactions induced by primary heavy nuclei and their fragments having a mean energy of about 5000 Bev were analyzed. The events were observed in emulsions flown in the upper atmosphere. Composite angular distributions of the events produced by the fragments (neutral, singly-charged, and multiply-charged) were obtained. The energies of the singly-charged fragments as calculated from their emission angles and the angular distributions were quite different. The multiplicities of particles produced by these fragments were estimated. For events with $N_h \leq 5$, $(n_s)_a = 14.4 \pm 2.2$; for $N_h = 0.1$, $(n_s)_a = 9.5 \pm 2.5$. The charged particle inelasticity was estimated to be 0.11 ± 0.02. The total inelasticity for N-nucleus reactions at 5000 Bev was about 0.20. (D.C.W.)

## Criticality Studies

**32894** (CONF-39-47) THEORY OF PULSED NEUTRON SOURCE MEASUREMENTS. Edward Garelis and John L. Russell, Jr. (General Electric Co. Vallecitos Atomic Lab., Pleasanton, Calif.). [nd]. Contract AT(04-3)-189. 22p.

From American Nuclear Society Annual Meeting, Salt Lake City, Utah, June 1963.

A method of utilizing pulsed neutron source measurements for the determination of the subcriticality of an assembly directly in terms of dollars is proposed. Essentially, the method determines the parameter ($k\beta/l$) using the complete response curve of a repetitively pulsed assembly after the quasi-equilibrium state is attained. This value of ($k\beta/l$) coupled with the usual $\alpha$ measurement, assuming the prompt decay constant to be dominant, yields the reactivity directly. The analytical model is based on a bare one-group diffusion theory system with m-delayed precursors. The application of these results to experiment shows that their applicability is much broader than the simple analytical model would indicate. (auth)

**32895** (HW-SA-2999) IDEALIZED PLUTONIUM DISSOLVERS AND THE "ALWAYS SAFE" CONDITIONS. W. A. Reardon and F. R. Czerniejewski (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [May 1, 1963]. Contract [AT(45-1)-1350]. 11p. (CONF-39-21)

From American Nuclear Society Meeting, Salt Lake City, Utah, July 1963.

A study was made to determine if some combination of plutonium metal and solution possesses a smaller critical mass than either the fully reflected metal system or a fully dissolved system. Primary results of the calculations are shown in a figure with the critical total mass (metal plus solution) presented as a function of the critical volume (metal plus solution) for various assumed central masses of plutonium metal. The "always safe" envelope is shown as a tangent curve and the lower portion of the homogeneous

curve. Critical total mass was also plotted against the critical solution concentration. It is shown that there are situations where the critical mass is smaller than the total mass when partially dissolved. (M.C.G.)

## Elementary Particles and Radiations

**32896** (ANL-6729) A SIMPLE GRAPHICAL METHOD IN THE ANALYSIS OF $SU_3$. S. Gasiorowicz (Argonne National Lab., Ill.). June 1963. Contract W-31-109-eng-38. 68p.

The commutation relations of the algebra of $SU_3$ are used to construct a simple graphical picture of the irreducible representations. The graphs are useful in the reduction of products of irreducible representations. A simple systematic method for the calculation of the generalized Clebsch-Gordan coefficients is also presented. (auth)

**32897** (BNL-6962) THE $K^-$-p TOTAL CROSS SECTION BETWEEN 2.7 AND 5.2 Bev/c. A. N. Diddens, E. W. Jenkins, T. F. Kycia, and K. F. Riley (Brookhaven National Lab., Upton, N. Y.). [1963]. Contract [AT(30-2)-Gen-16]. 12p. (CONF-46-47)

From American Physical Society Meeting, April 1963.

The $K^-$-p total cross section was measured between 2.7 and 5.2 Bev/c, by means of a transmission experiment. Points with about 3% statistical errors were obtained at momenta approximately 200 Mev/c apart. (auth)

**32898** (BNL-7105) PRELIMINARY STUDY OF RESONANCE PRODUCTION IN THE $\Xi$ K$\pi$ FINAL STATE. P. L. Connolly, E. L. Hart, et al. (Brookhaven National Lab., Upton, N. Y.); M. Goldberg, et al. (Syracuse Univ., N. Y.). [1963]. Contract AT-30-2-GEN-16. 15p. (BNL-A-76)

The K-$\pi$ and $\Xi$-$\pi$ mass distributions from $K^-$-p interactions at 2.3 Bev/c were obtained. The Dalitz plots show peaks corresponding to the $\Xi^*$ (1530), $K^*$ (880), and (probably) $K^*$ (730). Peaks corresponding to masses of 1660 and 1740 Mev were also observed. Evidence of considerable structure in the mass distributions was noted. Constructive interference of the parallel resonance channels $\bar{K}$-p $\rightarrow \begin{bmatrix} \Xi(1530) + K \\ K^* 730 + \Xi \end{bmatrix}$ and destructive interference of the channels $\begin{bmatrix} \Xi(1530) + K \\ K^* 880 + \Xi \end{bmatrix}$ seems to occur. The observed width for the squared mass ($\Xi^-$-$\pi^+$) was estimated to be 15 Mev. No evidence for the predicted peak at 1600 Mev was discovered; if the $\Xi^*$ (1600) occurs its production rate is less than $1/_{20}$ of the $\Xi^*$ (1530). (D.C.W.)

**32899** (CONF-46-80) NEUTRAL SCALAR THEORY WITH RECOIL. V. Barger and E. Kazes (Pennsylvania State Univ., University Park). [1963]. Contract [AT(30-1)-2133]. 25p.

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Using the fixed momentum transfer dispersion relation without subtraction and introducing a cutoff in the dispersion integrals for pion energies larger than $\sqrt{M\mu}$, the amplitude for scattering of pion (scalar and neutral, mass $\mu$) from nucleons (spinless, mass $M \gg \mu$) was calculated. The advantages gained by this approximation are primarily analytical: the scattering amplitude can be solved in terms of s- and p-waves alone for pion energies $< \sqrt{M\mu}$; and the full effect of the p-waves and of their ambiguities on the s-waves is displayed. The connection between the Castillejo-Dalitz-Dyson ambiguity and the unstable particle interpretation was also established in a special case. (auth)

**32900** (EFINS-63-29) THE STRONG AND WEAK INTERACTIONS OF BOUND $\Lambda$-PARTICLES. R. H. Dalitz (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies and Chicago. Univ.). [1963]. Contract AT(11-1)-264. 34p. (CONF-130-2)

From International Conference on Hyperfragments at St. Cergue, Mar. 1963.

Calculations on the S-wave $\Lambda$-N and $\Lambda$-$\Lambda$ interactions, binding energies for the p-shell hypernuclei, and the mesic decay and nonmesonic de-excitation of the $\Lambda$-particle are discussed. The theory behind the calculations, as well as the results and their interpretation, are considered. (D.C.W.)

**32901** (EFINS-63-32) THE OUTLOOK IN HYPERNUCLEAR PHYSICS. R. H. Dalitz (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies and Chicago. Univ.). [1963]. Contract AT(11-1)-264. 19p. (CONF-130-1)

From International Conference on Hyperfragments at St. Cergue, Apr. 1963.

Information on the properties of the nuclear interactions of hyperons, weak interactions of the hyperon ($\Lambda$), and properties of nuclei that could be obtained by studying hypernuclei is discussed. Experiments that should be able to give relevant information in the near future are considered. (D.C.W.)

**32902** (EFINS-63-35) VECTOR MESONS AS REGGE POLES IN PERTURBATION THEORY. Peter G. O. Freund and Reinhard Oehme (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies). May 1963. Contract AT(11-1)-264. 14p.

It is shown that vector mesons may become Regge particles in higher orders of renormalizable perturbation theory. (auth)

**32903** (EFINS-63-39) THE STRUCTURE OF THE WEAK INTERACTION $\Lambda + N \rightarrow N + N$. M. M. Block (Northwestern Univ., Evanston, Ill.) and R. H. Dalitz (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies and Chicago. Univ.). May 1963. Contract [AT(11-1)-264]. 11p.

Empirical evidence on the nonmesic decay of $\Lambda$-hypernuclei is analyzed in terms of the spin and isospin dependence of the weak interactions $\Lambda + p \rightarrow n + p$ and $\Lambda + n \rightarrow n + n$. The nonmesic decay rates for $_{\Lambda}He^4$ and $_{\Lambda}H^4$ were obtained by treating the $\Lambda$ de-excitation by different nucleons as incoherent and assuming the validity of the $\Delta I = 1/2$ selection rule for these interactions. The ratios of nonmesic to $\pi^-$ decay modes and of the first reaction to the second were calculated as $1.68 \pm 0.36$ and 0.5, respectively, for $He^5$ decay. The later ratio for $H^4$ was predicted to be $1/(8.8 \pm 3.2)$. Interpretation of the rates is discussed, and it is concluded that if the $\Delta I = 1/2$ rule holds for the $\Lambda$-N $\rightarrow$ N-N weak interaction and if present ideas about the current-current nature of weak interactions are valid, then the higher-order mesonic corrections to this primary four-fermion interaction must mask the simplicity of their primary form. (D.C.W.)

**32904** (EFINS-63-40) ON THE UNIQUENESS OF THE PARTIAL WAVE AMPLITUDES. A. P. Balachandran (Chicago. Univ. Enrico Fermi Inst. for Nuclear Studies). [1963]. Contract [AT(11-1)-264]. 8p.

It is assumed that all but a finite number N of partial waves associated with a two-body scattering amplitude are given, and the ambiguities associated with the remaining N waves are examined. It is proved that the N waves are

uniquely determined except possibly for an additive s-wave constant if the scattering amplitude has crossing symmetry or if, in one of the crossed channels, there exists an energy region where the scattering is purely elastic. For the former case, the precise nature of the scattering amplitude analyticity need not be known. (auth)

**32905** (LAL-1072) THE MEASUREMENT OF THE POLARIZATION OF RECOIL PROTONS FROM e-p SCATTERING AT 950 Mev. J. C. Bizot, J. Buon, J. Lefrançois, J. Perez Y Jorba, and Ph. Roy (Paris. Université, Orsay. École Normale Supérieure. Laboratoire de L'Accélérateur Linéaire). June 1963. 12p. (CONF-122-1)

From International Conference on Nucleon Structure, Stanford, Calif., June 1963.

Electrons were scattered in liquid H, and the polarization of the resultant protons was determined by scattering them in carbon block. Spark chamber around the carbon gave the necessary proton directions, energies, and ranges. A polarization of $-0.18 \pm 0.10$ was obtained, along with a horizontal polarization of $-0.02 \pm 0.09$ that is statistically consistent with zero, indicating validity of parity conservation. (D.C.W.)

**32906** (NP-12990) ELASTIC SCATTERING OF NEGATIVE PIONS BY PROTONS AT 2 Bev/c. Technical Report No. 11. D. E. Damouth, L. W. Jones, and M. L. Perl (Michigan. Univ., Ann Arbor. Coll. of Literature, Science, and the Arts). June 1963. Contract Nonr-1224(23). 60p. (ORA-03106-11-T)

The $\pi^-$-p differential elastic cross section at an incident pion momentum of 2 Bev/c was measured in a spark chamber experiment. Approximately 7000 events were obtained in the center of mass angular range $0.95 > \cos \Theta^* > -0.97$. The data show an approximately exponential diffraction peak that, when extrapolated to $\cos \Theta^* = 1.0$, is consistent with the optical theorem prediction. A second peak, with a maximum of 0.23 mb/sr is seen at $\cos \Theta^* = 0.2$. The backward scattering is not isotropic, but drops smoothly from 0.12 mb/sr at $\cos \Theta^* = 0$ to about 0.01 mb/sr at the most backward angles. An analysis in terms of a simple diffraction model and a fit in powers of $\cos \Theta^*$ are given. (auth)

**32907** (NYO-10271) AN INVESTIGATION ON THE MULTIPLE COULOMB SCATTERING IN NUCLEAR RESEARCH EMULSIONS. C. Dahanayake and P. J. Lavakare (Rochester, N. Y. Univ.). June 12, 1963. Contract [AT(30-1)-875]. 22p. (CONF-46-66)

From American Physical Society Meeting, Washington, D. C., April 1963.

A stack of Kodak emulsions, exposed to a 6.2-Bev proton beam, was used to study the behavior of spurious scattering in these emulsions. The effect of higher order differences was also considered. A detailed study of the behavior of the scattering constant as a function of cell length is also presented. The results indicate the necessity for a slight modification in the theory of multiple coulomb scattering. (auth)

**32908** (TID-7668) PROCEEDINGS OF THE CONFERENCE ON PHOTON INTERACTIONS IN THE BEV-ENERGY RANGE, HELD IN CAMBRIDGE, MASSACHUSETTS, JANUARY 26–30, 1963. Bernard T. Feld, ed. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). Contract [AT(30-1)-2098]. 168p.

Experimental and theoretical developments in quantum electrodynamics, electromagnetic form factors, scattering (Regge theory), and photoproduction are included. New techniques for producing and detecting particles and radiations are outlined, and developments in scanning and data reduction systems for spark chambers are described. Current worldwide electron accelerator development is summarized, and experiments in progress at the Cambridge Electron accelerator are reviewed. Separate abstracts were prepared for the nine sections of the proceedings. (D.C.W.)

**32909** (TID-7668(Sect.I)) QUANTUM ELECTRODYNAMICS AND ELECTROMAGNETIC FORM FACTORS. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 11p.

Experiments testing the theory of quantum electrodynamics were listed, and attempts to confirm experimentally the calculated radiative corrections were described. A proposal for measuring the pion form factor in electron pion production was discussed. Recent developments in the theory of quantum electrodynamics and in the determination and interpretation of nucleon form factors were presented. (D.C.W.)

**32910** (TID-7668(Sect.II)) REGGE POLES. I. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 16p.

Possible types of scattering amplitude behavior as a function of complex angular momentum were discussed, and theoretical studies on the type of behavior in a particle process containing unitarity, analyticity, and crossing symmetry were described. The possibility of Regge behavior exhibition by conventional field theories was also considered, and results of recent studies of elementary vector mesons and the high-energy limit of scattering amplitudes were presented. Existence of a spin-1 particle in the framework of dispersion theory was shown to induce a Regge trajectory of the Pomeranchuk type under certain conditions. (D.C.W.)

**32911** (TID-7668(Sect.III)) REGGE POLES. II. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 10p.

Measurements of the elastic differential cross sections for p-p and $\pi^-$-p at 7 to 20 Bev/c showed that the p-p results (shrinkage) would agree with the vacuum pole or three pole model, while the $\pi^-$-p date were inconsistent with the vacuum pole or three pole model. It was suggested that analysis of the two processes on the level of optics, not in terms of Regge poles, would make the cross sections more compatible. An experiment testing the Rosenbluth formula for elastic e-p scattering with a Regge trajectory instead of a photon is discussed. (D.C.W.)

**32912** (TID-7668(Sect. IV)) PHOTOPRODUCTION, EXPERIMENTAL. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 30p.

Experiments on $\pi^+$, $\pi^0$, $\eta$, $K^+$, and $\pi^-$ photoproduction and on gamma elastic scattering by protons are described. Analysis and interpretation of the events is also considered. A technique for measuring the decay rate (and from it the lifetime) of a particle decaying with the production of one or more photons is outlined. (D.C.W.)

**32913** (TID-7668(Sect. V)) PHOTOPRODUCTION, THEORY. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 16p.

Properties (cross sections, etc) of photoproduction processes that might be studied experimentally are examined. Calculation of the photopair production of heavy semiweakly interacting charged vector bosons in the Coulomb field of a nucleus is considered, and experimental and theoretical information on pion photoproduction and on pion nucleon scattering is presented. Difficulties in the latter calculations are outlined. Theoretical calculations of the cross section for pion electroproduction are shown to agree well with experiment. (D.C.W.)

**32914** (TID-7668(Sect.VI)) NEW EXPERIMENTAL APPROACHES. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 24p.

Diamond crystal arrangement for coherent bremsstrahlung, derivation of intense polarized $\gamma$ beams from multi-Bev electron accelerators, equipment for measuring the linear polarization of photons in the multi-Bev range, and a method for obtaining monochromatic bremsstrahlung from thin crystals are discussed. A technique for producing beams of polarized photons by interacting a laser beam with an electron beam is outlined, and procedures for obtaining polarized electrons are described. Capabilities and operation of storage rings are discussed. (D.C.W.)

**32915** (TID-7668(Sect.VII)) NEW DETECTION METHODS. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 29p.

Apparatus for detecting gamma rays (particularly spark and discharge chambers) are discussed, and the design and operation of a $\pi^0$ detector are described. The design and development of a sonic spark chamber is reported. Measurement of the cross section for gamma attenuation in hydrogen is discussed, as is the tagging of gamma rays by coinciding them with bremsstrahlung-producing electrons. A spark chamber automatic scanning system is also explained, and automatic or semi-automatic data reduction systems developed or in development for bubble chamber work are reviewed. (D.C.W.)

**32916** (TID-7668(Sect.VIII)) EXPERIMENTS IN PROGRESS AT CEA. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 25p.

Electromagnetic pair production experiments aimed at testing the theory of quantum electrodynamics and at searching for new particles are described. Muon pair photoproduction and electron pair production at wide angles are being investigated. Quantities sought and some preliminary results are discussed. Other experiments include electron scattering and meson photoproduction. Development of a 500-liter bubble chamber is reported. (D.C.W.)

**32917** (TID-7668(Sect.IX)) NEW ELECTRON ACCELERATORS. (Massachusetts Inst. of Tech., Cambridge. Lab. for Nuclear Science). 4p.

The status of the accelerator programs in Italy, France, Germany, Sweden, United Kingdom, United States, and Japan is briefly summarized. Some of the features and design characteristics of the accelerators are given. (D.C.W.)

**32918** (UCRL-10897) BARYON SPECTROSCOPY. Arthur H. Rosenfeld (California. Univ., Berkeley. Lawrence Radiation Lab.). July 9, 1963. Contract W-7405-eng-48. 32p. (CONF-122-2)

From International Conference on Nucleon Structure, Stanford Univ., June 1963.

Current experimental knowledge of the quantum numbers of baryons is surveyed, and an attempt is made to systematize this information. (auth)

**32919** (WAPD-T-1579) EXPLICIT FORMS AND RECURSION RELATIONS FOR THE QUANTITIES $T^n_{LL'}$. E. M. Gelbard and D. R. Harris (Westinghouse Electric Corp. Bettis Atomic Power Lab., Pittsburgh). Apr. 1963. Contract AT(11-1)-Gen-14. 13p. (CONF-39-55)

From American Nuclear Society Meeting, Salt Lake City, June 1963.

Various procedures were devised to evaluate the $T^n_{LL'}$ elements in T-matrices. A general closed form of expression was developed for the matrix elements, valid for all L,L', and N. Recursion relations were also developed, not for the T's themselves, but for closely related quantities. If it is necessary to compute certain isolated T's the analytic expression was found to be more convenient. If a block of $T^n_{LL'}$ values was computed, use of the recursion relation seemed more efficient. (M.C.G.)

**32920** CROSS SECTIONS FOR STRANGE PARTICLE PRODUCTION. [PART] II. V. S. Barashenkov, V. M. Maltsev, and Tzu-chang Huang (Joint Inst. for Nuclear Research, Dubna, USSR). Acta Phys. Polon., 23: 765-71(1963). (In English)

The cross sections for the production of strange particles in the antinucleon annihilation and in $\pi$-N interactions in the energy region $E \leq 3$ Bev were calculated. The resonance interactions of the producing particles are taken into account. The effective constants of the strange particle production were estimated. The multiple pion production was also treated for the case of the antinucleon annihilation. It was shown that all the experimental data may be explained if the resonance pion-pion interactions are taken into account. (auth)

**32921** THE PHENOMENOLOGICAL DESCRIPTION OF A RELATIVISTIC THREE-PARTICLE EMISSION. N. Karayianis (Indiana Univ., Bloomington). Ann. Phys. (N. Y.), 23: 1-22(July 1963).

A relativistic, phenomenological analysis of an arbitrary three-particle emission is made consistent with energy, momentum, and angular momentum conservation. The analysis parallels the general approach to the calculation of a decay rate from an interaction matrix with the unknown matrix elements serving as the arbitrary expansion coefficients. In this manner, the Lorentz invariants of the problem are easily traced. The result is specialized to a localized interaction for an emission of three spin one-half particles. It is shown that, in order to be consistent with Lorentz invariance, the emission must necessarily involve correlations between the momenta of the emitted particles. In the limit of three massless emitted particles, the most general energy spectrum for one of the product particles is calculated. The spectrum thus obtained is identical in form to the parametrized Michel spectra for the electron in muon decay, demonstrating that the Michel spectra have a fundamental origin. It is also shown that merely the added assumption of specific helicities for the emitted particles leads to results for muon decay identical to those obtained from the V-A law. (auth)

**32922** TWO-BODY METHODS FOR THREE-BODY PROBLEMS. L. M. Delves and G. H. Derrick (Univ. of New South Wales, Kensington). Ann. Phys. (N. Y.), 23: 133-59(July 1963).

The equivalent two-body method first introduced by Wigner for deriving triton wave functions is shown to be obtainable directly from the variation principle for the energy. It is extended to cover the general case of non-central, hard core interactions, for both the bound state and for scattering states, including the breakup reaction. Methods are given for systematically improving the wave function. (auth)

**32923** THE $\gamma$-RADIATION FIELD OF A WELL-COLLIMATED BEAM FROM A POINT SOURCE OF $Cs^{137}$ OR $Co^{60}$ IN IRON. O. I. Leipunskii, L. R. Kimel, and A. M. Panchenko. At. Energ. (USSR), 14: 577-9(June 1963). (In Russian)

A 1.0 curie source of $Cs^{137}$, and a 0.55 curie source of $Co^{60}$ were placed in a 16 × 18 × 25 cm block of iron plates. The well-collimated $\gamma$ beam was led out through an opening in the front wall of the assembly 0.7 cm in diameter and 8 cm long, and $\gamma$ measurements were taken with a small

halogen counter at various distances h along the beam from the exit point, and at various radial distances r in a plane normal to the beam. The γ readings for the $Cs^{137}$ source were taken at five fixed distances of 1.19, 2.56, 3.92, 5.28, and 6.65 free path lengths, and for the $Co^{60}$ source at 1, 4, and 5 free path lengths. The scattered γ reading in counts per minute was plotted as a function of the radial distance r for various values of h. The build-up factors for the scattered radiation were determined for various distances of h. The calculated build-up factors were in good agreement with the data of Goldstein and Wilkins (NYO-3075). Analogous experiments were also carried out for concrete, aluminum, and lead. (TTT)

**32924** MEASUREMENT INVARIANTS FOR STRONG INTERACTIONS WITH TETRADIMENSIONAL ISOBARIC SYMMETRY. Silvio Bonometto. Atti, Ist. Veneto Sci., Lettere Arti, Classe Sci. Mat. Nat., 120: 327-44(1961-62). (In Italian)

A study is made to determine if the scheme proposed by Tiomno (Nuovo cimento, 7: 200(1957) and Dallaporta (Proceedings of the Conference on Mesons and Recently Discovered Particles, V: 3(Padua-Venice 1957)) can be justified by a generalized gauge procedure. (J.S.R.)

**32925** INFRA-PARTICLES IN THE QUANTUM FIELD THEORY. B. Schroer (Universität, Hamburg). Fortschr. Physik, 11: 1-32(1963). (In German)

It is shown that in the presence of particles of zero rest mass the spectral assumptions of the quantum field theory have to be modified. Particles coupled to zero-rest-mass particles may not be eigenstates of the mass operator. In such a case the usual asymptotic condition is not valid and the Hilbert space has an entirely different structure from the Hilbert space of normal quantum field theory. Quantum electrodynamics provides an example for this situation. The electron is an infra-particle, i.e., an almost discrete eigenstate of the mass operator. (auth)

**32926** REGULARITY OF THE T MATRIX IN THE CASE OF DIRAC POTENTIAL SCATTERING. Antonio Pagnamenta (Univ. of Maryland, College Park). J. Math. Phys. (N. Y.), 4: 1020-8(Aug. 1963).

Applying Hunziker's method to the case of Dirac potential scattering, analyticity of the T matrix in energy and momentum transfer is proved. The conditions on the potential are somewhat weaker, and the domains of analyticity contain the known ones as special cases. (auth)

**32927** REAL UNITARY REPRESENTATION OF THE MANY-CHANNEL S MATRIX FOR COMPLEX l AND E. Hong-Mo Chan (Inst. for Advanced Study, Princeton, N. J.). J. Math. Phys. (N. Y.), 4: 1042-7(Aug. 1963).

A representation is established for the multichannel S matrix in terms of a matrix function A(l,E) and a scalar function B(l,E), both holomorphic in the domain formed by the product of the whole finite l plane with the finite E plane, cut only along the left-hand dynamical cut. The representation satisfies the known analytic properties of S(l,E), and also all the generalized unitarity conditions of Peierls, LeCouteur, and Newton. The reality condition on S for complex l and E is guaranteed by a simple condition on A and B. (auth)

**32928** RELATIVISTIC POTENTIAL SCATTERING. Reese T. Prosser (Massachusetts Inst. of Tech., Cambridge). J. Math. Phys. (N. Y.), 4: 1048-54(Aug. 1963).

The scattering properties of the relativistic two-body problem, governed by the Dirac equation, are investigated. It is shown rigorously that the associated hamiltonians are self-adjoint, that the associated wave operators exist, and that the scattering operator exists and is unitary, all under suitable conditions on the potential. These conditions on the potential are analogues of those required for the nonrelativistic two-body problem governed by the Schrödinger equation. (auth)

**32929** FORMULATION OF THE MANY-BODY PROBLEM FOR COMPOSITE PARTICLES. M. Girardeau (Univ. of Chicago). J. Math. Phys. (N. Y.), 4: 1096-1115(Aug. 1963).

The many-body problem for a system of composite particles is formulated in a way that takes explicit account of the composite nature of these particles and allows a clear separation between interatomic and intraatomic interactions. A second-quantization representation, fully equivalent to the conventional representation in which nuclei and electrons appear explicitly, is developed in terms of atomic annihilation and creation operators satisfying elementary Bose or Fermi commutation relations. All effects of the composite nature of the atoms are exactly contained in the interatomic and intraatomic matrix elements and in certain integrals. An application is made to the problem of Bose condensation of fermion pairs. (auth)

**32930** EXCLUSION OF CENTER-OF-MASS MOTION IN THE IDENTICAL PARTICLE SYSTEM. J. Kalade (Yu. A. Kalade), V. Sugurovas (V. K. Shugurov), and A. Janavicius (A. I. Yanavichyus) (Inst. of Geology and Geography, Academy of Sciences, Lithuanian SSR). Lietuvos TSR Mokslu Akad. Darbai, Ser. B, 1(32): 13-20(1963). (In Russian)

A method is suggested for developing wave functions for relative motion in a system of N identical particles. The transition from coordinate $r'_i$, with an initial function at an arbitrary point, to the coordinate $r_i = \sum_{k=1}^{N} a_{ik} r'_k$, $\rho_c = (1/N) \Sigma r'_k$, where i = 1, . . . . , N-1, was accomplished by a transformation using a nondegenerate matrix. Coordinates $r_i = r'_i - r'_N$ expressing the (N-1) particle positions in relation to the Nth position were utilized, and wave functions were constructed by means of genealogical and Clebsh-Gordan coefficients. Calculations of matrix elements were also analyzed. (tr-auth)

**32931** MULTIPLE SCATTERING MEASUREMENTS IN THE PRESENCE OF ENERGY LOSSES. A. Marques (Centro Brasileiro de Fisicas, Rio de Janeiro and Faculdade Nacional de Filosofia, Rio de Janeiro). Nucl. Instr. Methods, 23: 264-8(June 1963). (In English)

A first-order correction to the estimate of true scattering that accounts for small energy losses is presented. Energy values obtained from scattering measurements performed on pions, starting at 8 and 12 mm residual range, agree with values taken from range-energy tables when the original observations are treated according to the method developed throughout. (auth)

**32932** SCATTERING OF POLARIZED NEUTRONS BY α-PARTICLES. T. H. May, R. L. Walter, and H. H. Barschall (Univ. of Wisconsin, Madison). Nucl. Phys., 45: 17-26(July 1963). (In English)

The asymmetry in the elastic scattering by helium of partially polarized neutrons was measured for neutron energies between 2 and 24 Mev. Up to neutron energies of 17 Mev the variation of the measured asymmetry with scattering angle agrees with calculations based on published n-α phase shifts. At 24 Mev published phase shifts do not fit the results well. The measurements yield values of the polarization of neutrons from the reactions that served as the neutron sources. (auth)

**32933** FERMION REGGE POLES AND ASYMPTOTICS OF SCATTERING OF MESONS ON NUCLEONS THROUGH LARGE ANGLES. V. N. Gribov (Inst. of Physics and Tech., Leningrad). Nucl. Phys., 45: 65-71(July 1963). (In English)

The Regge poles describing a set of fermions and determining the asymptotic behavior of elastic scattering for large angles are shown to possess several characteristics: the Regge poles of partial amplitudes with different parities for a given j coincide when the square of the energy in the center of inertia system u tends to zero, the poles of these amplitudes become complex conjugate for $u < 0$. This leads to a specific oscillatory behavior of the elastic scattering amplitude in the region of large angles. (auth)

**32934** ON THE VECTOR FORM FACTOR IN PION BETA DECAY. Ian Duck (Univ. of Southern California, Los Angeles). Nucl. Phys., 45: 243-52(July 1963). (In English)

The pion vector form factor in the decay $\pi^{\pm} \rightarrow \pi^0 + e^{\pm} \pm \nu$ is calculated without the assumption of a conserved vector current in the weak interaction Lagrangian by assuming the vector form factor to satisfy an unsubtracted dispersion relation. In the approximation that only the $\pi$-$\pi$ and N-$\bar{N}$ intermediate states are considered, a set of coupled integral equations for the pion and nucleon weak vector form factors is derived. These integral equations are solved numerically with a simple trial function chosen to make the integrals converge. The pion vector form factor obtained is comparable to that obtained unequivocally from the conserved vector current theory. (auth)

**32935** POLARIZATION IN NEUTRON–DEUTERON ELASTIC SCATTERING AT 1.0 Mev. A. F. Behof, G. P. Lietz, S. F. Trevino, and S. E. Darden (Univ. of Notre Dame, Ind.). Nucl. Phys., 45: 253-4(July 1963). (In English)

The neutron polarization produced in the scattering of 1-Mev neutrons by deuterons has been remeasured for a c.m. scattering angle of 110°. A polarization $P_2 = 0.013 \pm 0.021$ was measured at this energy and angle. (auth)

**32936** SOME REMARKS ON SYMMETRIES SHARED BY STRONG AND WEAK INTERACTIONS. K. Venkatesan and T. S. Santhanam (MATSCIENCE, Madras). Nucl. Phys., 45: 255-9(July 1963). (In English)

A slight modification of the set of transformations suggested by Treiman and Pais and extended by Fujii to include K interactions is shown to leave a wide class of weak interaction Hamiltonians invariant under these transformations and to lead to the experimentally observed result, $\alpha_{\Xi} = -\alpha_{\Lambda}$. The product of these transformations is shown to be an R-invariance which is consistent with an octet symmetry for the baryons and bosons. The transformations are extended to include the leptons and some consequences are given. (auth)

**32937** UPPER BOUND ON THE NEUTRON–DEUTERON DOUBLET SCATTERING LENGTH. I. MATRIX ELEMENTS OF THE HAMILTONIAN. L. M. Delves and J. N. Lyness (Univ. of New South Wales, Kensington, Australia). Nucl. Phys., 45: 296-312(July 1963). (In English)

Kinetic and potential energy matrix elements are given for neutron-deuteron scattering in the $J = 1/2$, $\pi = +1$ state. (auth)

**32938** THE PROPAGATOR FOR A PARTICLE IN THE PRESENCE OF A ONE-DIMENSIONAL SQUARE-WELL POTENTIAL. J. L. Beeby (Univ. of Manchester, Eng.). Proc. Cambridge Phil. Soc., 59: 607-13(July 1963).

The propagator for a particle in the presence of a one-dimensional square-well potential is calculated. The related t-function is written in Fourier transform. The analytic properties of the propagator and t-function are discussed. (auth)

**32939** CORRECTIONS OF FINITE GEOMETRY AND ENERGY IN THE ANALYSIS OF FAST NEUTRON POLARIZATION. I. Mînzatu and A. Calboreanu (Inst. of Atomic Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 157-71(1963). (In English)

The analysis of the polarization of a fast-neutron beam by scattering-asymmetry measurements is considered. Corrections necessitated by the fact that the scatterer and detector are finite (rather than points), as well as corrections introduced by the energy dispersion of the beam, are approximated. These approximations are then introduced into the equation relating scattering asymmetry to beam polarization. (T.F.H.)

**32940** CP INVARIANCE AND THE CONCEPT OF ANTIPARTICLES. Ken-ichi Ono (Tokyo Univ.). Sci. Papers Coll. Gen. Educ., Univ. Tokyo, 13: 23-6(June 1963).

It is shown that if the principle of symmetry in particle interactions is assumed, then every particle must have its antiparticle, including the cases of particles that are identical with their antiparticles. It is also shown that if the principle of symmetry is assumed, the CP invariance becomes self evident. (C.E.S.)

**32941** ON THE SPIN AND PARITY OF THE RESONANT STATE $Y_0$. Chong-shou Gao (Peking Univ). Sci. Sinica (Peking), 12: 1073-4(July 1963). (In English)

It is shown that the $Y_0^*$ may have spin-parity of $3/2^-$. The possibility of the existence of a family of unstable baryons with spin parity of $3/2^-$ is discussed. A list of baryons, mesons, and their resonance states with the spin-parity assignments of $0^-$, $1^-$, $1/2^+$, and $3/2^-$ is also given. (C.E.S.)

**32942** ON SOME ANALYTICAL PROPERTIES OF THE AMPLITUDES OF INELASTIC PROCESSES. I. I. Kostyrko (Inst. of Mathematics, Kiev). Ukr. Fiz. Zh., 8: 549-54 (1963). (In Ukrainian)

The conditions are found for invariants and masses of external particles, under which the amplitudes of scattering from the fifth and sixth external pulses in any order of perturbation theory are analytical in complex planes with sections. (auth)

**32943** ON THE AXIOMATIC THEORY OF THE ELEMENTARY PARTICLES SYMMETRIES. Y. V. Novozhilov. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 7-14(1963). (In Russian)

The problem of the maximal symmetry in the axiomatic theory is considered, and the origin of the 3-dimensional isospin symmetry is investigated. The special isospin properties of the electromagnetic field are also clarified. (auth)

**32944** ON THE ONE POSSIBILITY IN CALCULATING THE DISCONTINUITIES OF THE TRANSITION AMPLITUDES ABOVE THE THRESHOLD OF CREATION MORE THAN TWO PARTICLES. F. M. Kuni and V. A. Franke. Vestn. Lenningr. Univ., No. 4, Ser. Fiz. i Khim., No. 1, 15-19(1963). (In Russian)

The method of calculation of the inelastic absorptive part of partial amplitudes on the physical cut is proposed. (auth)

**32945** PRODUCTION OF HYPERONS ($\Xi^-$) BY MESONS ($\pi^-$) WITH MOMENTUM 7 AND 8 Bev/c. Kang-ch'ang Wang, Tsu-tseng Wang, N. M. Viryasov, et al. Wu Li Hsueh Pao, 17: 205-13(May 1961). (In Chinese)

The production cross sections of hyperons ($\Xi^-$) by mesons ($\pi^-$) of momenta 6.8 and 8 Bev/c were found to be 3.6 and 10.6 $\mu b/N$, respectively. The mass of the hyperon ($\Xi^-$) was 1317.0 ± 2.2 Mev and the lifetime was $3.5 \times 10^{-10}$ sec. (tr-auth)

**32946** THE AMBIGUITY IN ASSIGNING PHASE SHIFT OF NUCLEON-DEUTERON SCATTERING. Hsueh-dan Shih (Inner Mogolian Univ.). Wu Li Hsueh Pao, 18: 184-7(Apr. 1962). (In Chinese)

By using the fact that the properties of differential cross section are invariant under the rotation of total spin, the ambiguity in assigning phase shift of the nucleon-deuteron scattering is discussed. The Minami transformation for the nucleon-deuteron scattering is given. (auth)

**32947** MEASUREMENT OF THE PANOFSKY RATIO BY THE METHOD OF GAMMA-GAMMA COINCIDENCES. A. F. Dunaitsev, Yu. D. Prokoshkin, V. S. Pantuev, Syao-wei Tang, and M. N. Khachaturyan. Wu Li Hsueh Pao, 18: 218-20(Apr. 1962). (In Chinese)

The ratio of the probability of two capture processes of stopped negative pions in hydrogen was measured by the $\gamma$-$\gamma$ coincidence method. The experimental result is equal to 1.40 ± 0.08. This value agrees with the data on photoproduction and scattering of pions. (auth)

**32948** THE DERIVATION OF ONE-PARTICAL GREEN'S FUNCTION BY THE METHOD OF DISPERSION RELATION. Ning Hu (Peking Univ.). Wu Li Hsueh Pao, 18: 509-13(Oct. 1962). (In Chinese)

The Green's function of a single $\pi$ meson is obtained by the method of dispersion relation utilizing the analytic and unitary properties of the nucleon-antinucleon scattering amplitude. No renormalization procedure is needed. (auth)

**32949** LOW ENERGY PION-NUCLEON SCATTERING AND PION–PION INTERACTION. Hong-an Peng (Peking Univ.). Wu Li Hsueh Pao, 18: 621-8(Dec. 1962). (In Chinese)

Starting from the dispersion relation low energy $\pi$-N scattering amplitude with positive isospin is discussed. It is shown that for $P_{\frac{3}{2}}^{(+)}$-wave, the results evaluated from CGLN formula are essentially in agreement with experiment. When compared with experiment, the sign of CGLN results for S-wave is wrong. Further the results increase very rapidly with energy and exceed the limit allowed by the unitary condition. From analysis it is shown that one cannot solve this problem and at the same time keep the agreement of the calculated $P_{\frac{3}{2}}^{(+)}$-wave results with experiment by introducing a $\pi$-$\pi$ S-wave interaction. But alternatively if one subtraction is performed on the $\pi$-N S-partial wave dispersion relation then the results agree with experiment fairly well. So it is likely that the $\pi$-$\pi$ S-wave interaction plays an unimportant role in it. (auth)

**32950** ON A CERTAIN MODEL OF $\pi\pi$-INTERACTION. A. A. Afonin and Ya. I. Granovskii (Inst. of Nuclear Physics, Academy of Sciences, Kazakh SSR). Zh. Eksperim. i Teor. Fiz., 44: 1896-1900(June 1963). (In Russian)

Pion interaction via an intermediate vector meson is considered. The model describes $\pi$-$\pi$ resonance and asymptotically yields a constant total cross section and diffractional angular distribution. Other properties of the model are also not inconsistent with the experimental data. (auth)

**32951** APPLICATION OF THE METHOD OF MAJORIZATION OF FEYNMAN DIAGRAMS FOR PROVING THE DISPERSION RELATIONS. M. A. Mestvirishvili (Inst. of Cybernetics, Academy of Sciences, Georgian SSR). Zh. Eksperim. i Teor. Fiz., 44: 1901-6(June 1963). (In Russian)

The method of majorization of Feynman diagrams is applied for investigating elastic scattering of pseudoscalar $\pi$ and K mesons on K mesons. Primitive diagrams for these processes are found and their analytical properties studied. (auth)

**32952** ON THE RELATION BETWEEN VARIOUS METHODS FOR DESCRIBING THE INTERACTION OF HIGH ENERGY PARTICLES. I. I. Roizen and D. S. Chernavskii (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 44: 1907-14(June 1963). (In Russian)

The relation between the moving-pole method, strip approximation and one-meson approximation is discussed. It is shown that despite the great differences in mathematical form and concrete problems treated by the three methods, they are essentially similar in the respect that the assumptions underlying them are very nearly the same. (auth)

**32953** INVARIANT PARAMETRIZATION OF LOCAL OPERATORS. A. A. Cheshkov and Yu. M. Shirokov (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 44: 1982-92 (June 1963). (In Russian)

A general method is developed in which matrix elements of local operators of an arbitrary tensor or spinor dimension, given between states with either one or several particles of any masses and spins, can be expressed in terms of invariant form factors. Such an invariant parametrization is necessary for investigation of various dispersion relations and for investigation of the structure of elementary particles and of the limits of applicability of concepts regarding the structure of space-time. (auth)

**32954** THEORY FOR DETERMINING THE SIGN OF THE MASS DIFFERENCE OF $K_1^0$- AND $K_2^0$- MESONS. S. G. Matinyan (Inst. of Physics, Academy of Sciences, Georgian SSR). Zh. Eksperim. i Teor. Fiz., 44: 2011-15(June 1963). (In Russian)

Passage of a beam of $K_2^0$ mesons through a stack of many plates is considered from the standpoint of determining the sign of the $K_1^0$ and $K_2^0$ meson mass difference. The yield of regenerated $K_1^0$ mesons compared to that from a pair of thin plates can be considerably increased by using a large number of thin plates; the simplicity of the formulas for determination of the sign of the mass difference $\Delta m$ is retained. In the light of possible violations of the $\Delta S = \Delta Q$ rule the method for determining the sign of $\Delta m$ on the basis of lepton decays is discussed. It is also suggested that the $K^0$ and $\overline{K}^0$ meson charge-exchange effect may be employed for determining the sign of $\Delta m$. (auth)

**32955** CONTRIBUTION OF STRONG INTERACTIONS TO THE PHOTON GREEN FUNCTION. V. G. Pivovarov (Inst. of Mathematics, Academy of Sciences, Siberian SSR). Zh. Eksperim. i Teor. Fiz., 44: 2023-8(June 1963). (In Russian)

The variation of the photon Green function that occurs when strong interactions between virtual $\pi$ mesons are taken into account is considered, and the variation of the total differential cross section for processes occurring via virtual photons is analyzed. (auth)

**32956** REGGE POLES IN THE PROBLEM OF A QUASI-CLASSICAL POTENTIAL WELL. A. Z. Patashinskii, V. L. Pokrovskii, and I. M. Khalatnikov (Inst. of Physics, Academy of Sciences, USSR and Inst. of Thermal Physics, Academy of Sciences, Siberian SSR). Zh. Eksperim. i Teor. Fiz., 44: 2062-78(June 1963). (In Russian)

The problem of scattering-phase poles (Regge poles) is investigated in the case of a rectangular spherical potential well. The scattering phase in this case can be explicitly expressed in terms of Bessel functions. For determining

the scattering-phase poles, use is made of a previously developed technique for tracing the properties of the phase along the level lines. Two sets of poles are found, "physical" and "nonphysical". The character of pole motion upon change of energy is elucidated. Some general relations between the number of levels and number of resonances are established. A potential well of the simplest type is chosen in order to exclude unnecessary complications in the calculations. The results are essentially the same for potentials with a singularity outside the point r = 0. (auth)

**32957** RESTRICTIONS ON THE ASYMPTOTIC VALUES OF THE CROSS SECTIONS IMPOSED BY THE REGGE POLES HYPOTHESIS. I. B. Khriplovich (Inst. of Nuclear Physics, Academy of Sciences, Siberian SSR). Zh. Eksperim. i Teor. Fiz., 44: 2079-80(June 1963). (In Russian)

The asymptotic value of the amplitude defined by the n-th order Regge pole is presented. Assuming analyticity of $l(s)$ near $s = 0$ and employing the unitarity condition, it is shown that the total cross section does not increase more rapidly than the logarithm of energy. (auth)

**32958** RADIATIVE CORRECTIONS TO SCALAR MESON PAIR PRODUCTION IN ELECTRON-POSITRON COLLISIONS. V. V. Sokolov (Inst. of Nuclear Physics, Academy of Sciences, Siberian SSR). Zh. Eksperim. i Teor. Fiz., 44: 2081-6(June 1963). (In Russian)

The perturbation theory series for $\pi$ meson pair production in electron-positron collisions is evaluated in the double-logarithmic approximation. (auth)

**32959** ON THE LEE AND YANG THEORY OF CHARGED VECTOR MESONS. A. D. Sukhanov (Karpov Inst. of Physics and Chemistry, USSR). Zh. Eksperim. i Teor. Fiz., 44: 2087-9(June 1963). (In Russian)

The theory of charged vector mesons ($\xi$-limiting process) proposed by Lee and Yang is derived within the framework of the Lagrange formalism and thus can be treated (for finite values of $\xi$) as a consistent modification of the Pauli-Willars regularization. An interpretation is presented of two Lee and Yang postulates, which are employed for carrying out the limiting transition $\xi \to 0$. It is found that, whereas the second postulate can be formulated in accordance with usual quantum field theory concepts, the validity of the first postulate is questionable, since its use involves the dubious exclusion of the most important terms in nonrenormalizable theories. (auth)

**32960** COMPTON EFFECT ON RELATIVISTIC ELECTRONS AND THE POSSIBILITY OF OBTAINING BEAMS OF HARD $\gamma$-QUANTA. F. R. Arutyunyan and V. A. Tumanyan (Inst. of Physics, Yerevan, USSR). Zh. Eksperim. i Teor. Fiz., 44: 2100-3(June 1963). (In Russian)

The possibility of obtaining beams of hard $\gamma$ quanta as a result of the Compton effect on relativistic electrons is considered. It is shown that the photon energy distribution should significantly differ from the bremsstrahlung spectrum and that at comparatively small energies of the scattered photons, relatively monoenergetic hard $\gamma$ quanta are produced. The fluxes of $\gamma$ quanta thus produced are comparable to the corresponding values for the bremsstrahlung radiation. (auth)

**32961** CLASSICAL MODEL OF A CHARGED PARTICLE WITH AN ANGULAR MOMENTUM. A. S. Kompaneets (Inst. of Physical Chemistry, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 44: 2169-72(June 1963). (In Russian)

It is shown that by balancing the repulsive electromagnetic field by an attractive vector meson field, a stable classical model of a charged particle can be constructed that possesses a mechanical angular momentum. (auth)

**32962** MATRIX STRUCTURE OF THE MESON–PHOTON, NUCLEON–PHOTON AND PHOTON–PHOTON SCATTERING AMPLITUDES AT HIGH ENERGIES. V. D. Mur (Moscow Inst. of Engineering Physics). Zh. Eksperim. i Teor. Fiz., 44: 2173-9(June 1963). (In Russian)

By means of the complex moment method it is demonstrated that invariant functions describing $\pi$–$\gamma$, N–$\gamma$, and $\gamma$–$\gamma$ scatterings can be factorized. The consequences for observable quantities to which the factorization may lead are indicated. (auth)

**32963** STUDIES OF THE RELATIVISTIC THEORY OF THE SPIN ELECTRON IN RIEMANNIAN SPACE. Kuang-Lai Chao. Thesis, Brunswick, Technische Hochschule, 1962. 56p. $2.00.

A theory of spin electrons based on Dirac theory of electrons in Riemannian space is given. A simpler presentation of the general Dirac equation is included. The equations are also valid in Minkowsky space. The motion of a spin electron in a weak static central-symmetric gravitational field was investigated. The expressions for the Dirac equation given by various authors are compared. (Gmelin Inst.)

**32964** PHOTOPRODUCTION OF POSITIVE $\pi$ MESONS WITH HYDROGEN. K. Luebelsmeyer. Thesis, Bonn, Universität, 1962. 132p. $2.00.

The production of positive $\pi$ mesons by the interaction of photons with protons is studied. A bremsstrahlung beam of the electron-synchrotron in Bonn was used for these experiments. The energy distribution of this beam was measured, and the results are compared with theoretical calculations. The construction of a range telescope with 5 counters for the detection of mesons is described. The differential cross section for the production of $\pi^+$ mesons was measured as a function of the angle. The results of these measurements are compared with values from calculation by the Monte Carlo method. (Gmelin Inst.)

**32965** PROTON-NUCLEON INTERACTIONS IN NUCLEAR EMULSION AT 28 Bev/c. H. C. Glahe (Niagara Univ., [New York]), P. D. Bharadwaj, and P. L. Jain. 8p. (CONF-46-57).

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

About 200 stars with $N_h \leq 1$ were found by scanning along the tract in nuclear emulsion exposed to 28 Bev protons. The effective target mass distribution of the interactions is determined from multiple scattering and ionization measurements as well as from the angular distribution of the secondary tracks. This distribution indicates that an appreciable fraction of the events might be attributed to peripheral nucleon-nucleon collisions. An effort is made to derive the general relation between the effective target mass and the energy of the primary particle. These results are further correlated to the inelasticity of the interactions. Verification of a method for the determination of the primary energy of jets is also discussed. (auth)

**32966** A RESONANCE MODEL FOR $\gamma + N \to Y + K$. N. A. Beauchamp and W. G. Holladay (Vanderbilt Univ., Nashville). 12p. (CONF-46-60).

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

A model that includes a resonance proposed by Kanazawa is used to describe the low energy behavior of the reaction $\gamma + N \to K + \Lambda$. Only those contributions from the N, K, K*,

and $p_{\frac{1}{2}}$ nucleon resonance of Kanazawa are considered. The resonance is centered at 1718 Mev with a full width of 120 Mev. The parameters in the model are the coupling constants at the N-Λ-K and N-Λ-K* vertices, the form factors at the γ-K-K* vertex, and the height of the resonance. These parameters are evaluated by fitting the Cornell differential cross-section data for the process $\gamma + p \rightarrow \Lambda^0 + K^+$. The use of these parameters does not yield results in agreement with the one measured value of polarization of the Λ. (auth)

**32967** NONADIABATICITY IN POTENTIAL SCATTERING. S. Tani (New York Univ., New York). 7p. (CONF-46-59).

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

If the magnitude of the potential is changed by a small amount, an eigenfunction of the hamiltonian will be perturbed by a small amount only; this is an idea fundamental in scattering theory. Mathematically this may be formulated in the conjecture that a unitary transformation, which connects a plane wave with an eigenfunction in the presence of a potential, can be constructed by summing a Born series. The Born series may have a finite radius of convergence, but the sum may be used outside such a limit, embodying an analytical continuation in the strength of potential. In constructing the unitary transformation, a delta function and a principal value of difference in energy are used along with their products. This argument is not valid if a potential is attractive and able to support a bound state; it must be revised at low energies. Some one-dimensional scattering problems are anomalous even for a repulsive potential at zero energy. In these cases the zero energy phase shift does not vanish if the high energy limit is set equal to zero. (auth)

## Neutron Physics

**32968** (BNL-765) OPTICAL MODEL NEUTRON TRANSMISSION COEFFICIENTS, 0.1 TO 5.0 Mev. E. H. Auerbach and F. G. J. Perey (Brookhaven National Lab., Upton, N. Y.). July 1962. Contract AT-30-2-GEN-16. 364p. (BNL-T-286)

Neutron transmission coefficients between 0.1 and 5.0 Mev were calculated using a local optical potential with parameters due to Bjorklund and Fernbach and a non-local optical potential with parameters due to Perey and Buck. In both cases, a single set of parameters is used for all masses and spin-orbit coupling is taken into account. The results are given in tabular form convenient for use in inelastic scattering calculations. (auth)

**32969** (BNL-6949) THE ENERGY DEPENDENT MILNE PROBLEM WITH A SIMPLE SCATTERING KERNEL. M. M. R. Williams (Brookhaven National Lab., Upton, N. Y.). Mar. 1963. Contract AT-30-2-GEN-16. 32p. (CONF-39-26)

From American Nuclear Society Annual Meeting, Salt Lake City, June 1963.

An exact solution to the energy dependent Milne problem was obtained using a simple scattering model. The extrapolation distance and angular distribution at the surface of the half-space were calculated using the free gas scattering cross sections. Zero absorption is assumed throughout. It is shown by comparison with numerical results obtained from THERMOS and variational methods that the extrapolation distance and angular distribution are insensitive to the specific properties of the scattering kernel and depend mainly on the energy dependence of the mean free path. (auth)

**32970** (CONF-11-5) WATER SPECTRA AND ENERGY EXCHANGE KERNELS. P. B. Daitch and M. J. Ohanian (Rensselaer Polytechnic Inst., Troy, N. Y.). July 31, 1963. Contract [AT(30-3)-328]. 12p.

For Presentation at American Nuclear Society Winter Meeting, Washington, D. C., Nov. 1963.

The Nelkin model was used to obtain the spectrum, and the mass-2 gas, and the Nelkin models were used to calculate a quantity containing model dependent information. Comparison with experiment showed that neither model fit the data very well and that below kT the Nelkin model was more precise. The Nelkin model, however, did not estimate the deviation from the Maxwellian component (subtracted for the comparison) of the spectrum very well. (D.C.W.)

**32971** (CONF-11-6) ASYMPTOTIC NEUTRON SPECTRA IN MULTIPLYING MEDIA. R. E. Slovacek, R. R. Fullwood, E. R. Gaerttner (Rensselaer Polytechnic Inst., Troy, N. Y.); and D. R. Bach (Knolls Atomic Power Lab., Schenectady, N. Y.). [1963]. Contract [AT(30-3)-328]. 9p.

For Presentation at American Nuclear Society Meeting, Washington, D. C., Nov. 1963.

Asymptotic low-energy neutron spectra were measured for two multiplying systems. The reentrant hole spectrum (scalar flux) and the surface leakage spectrum were obtained for both assemblies using the pulsed-source chopper technique at a linear accelerator. By increasing the time between the linear accelerator pulse and the chopper opening, the spectrum was observed to approach an asymptotic distribution after 50 to 100 μsec, depending on the spectrum source and the experimental arrangement. The first multiplying medium consists of an array of fuel strips in water with a multiplication of about 4. To reduce the uncertainties in the calculation due to system boundaries and the self-shielding factor, a homogeneous medium was constructed of fuel blocks. This paraffin-fuel dispersion was stacked and surrounded by a Cd-lined $B_4C$ shield box. No significant multiplication was measured for this thin assembly. The agreement between calculated and measured scalar spectra is good. (M.C.G.)

**32972** (CONF-11-7) DIFFUSION PARAMETERS OF WATER FOR VARIOUS SCATTERING KERNELS. Gerald P. Calame (Rensselaer Polytechnic Inst., Troy, N. Y.). [1963]. Contract AT(30-3)-328. 28p.

From American Nuclear Society Meeting, Washington, D. C., November 1962.

Some diffusion parameters of water were computed with various thermal neutron scattering laws. It was found that the diffusion cooling coefficient, in particular, is reasonably sensitive to the scattering law, but that the diffusion cooling coefficients predicted by the Radkowsky and Nelkin kernels are in fortuitous agreement. The coefficients computed for the Nelkin kernel, when treated in a manner consistent with the way in which experimental data are treated, are in reasonable agreement with the results of a recent experiment. (auth)

**32973** (CONF-39-46) VELOCITY POLYNOMIALS IN NEUTRON THERMALIZATION. Charles S. Shapiro and Noel Corngold (Brookhaven National Lab., Upton, N. Y.). Feb. 1963. Contract [AT(30-2)-Gen-16]. 6p.

From American Nuclear Society Meeting, Salt Lake City, June 1963.

The time decay of a neutron pulse in a homogeneous medium and the steady state distribution of neutrons from a

localized source were studied by approximating the neutron density by a velocity polynomial × a Maxwellian. Eigenvalues (particularly those for the diffusion cooling coefficient) obtained with these velocity polynomials converge much more rapidly than those obtained with the usual energy polynomials. (D.C.W.)

**32974** (GA-4328) NEUTRON THERMALIZATION IN ZIRCONIUM HYDRIDE. G. K. Houghton, J. R. Beyster, J. C. Young, and G. D. Trimble (General Atomic Div. General Dynamics Corp., San Diego, Calif.). June 12, 1963. Contract AT(04-3)-167. 34p. (CONF-39-24)

Molecular models used to explain neutron thermalization in zirconium hydride are reviewed, and results obtained with the models are compared with recent experimental results. The Einstein oscillator model and the phenomenological description of Miller each explain some of the data, but they predict the temperature dependence of the neutron spectra quite differently. This dependence for zirconium hydride poisoned with boron was measured by time-of-flight means. The spectrum was found to shift markedly with temperature, almost as predicted by the Einstein models. (D.C.W.)

**32975** DETERMINATION OF THE DIFFUSION PARAMETERS OF THERMAL NEUTRONS IN POISONED WATER. N. Mateescu and V. Nahorniak (Inst. of Atomic Physics, Bucharest). Acad. Rep. Populare Romine, Studii Cercetari Fiz., 14: 271-5(1963). (In Rumanian)

The diffusion parameters of thermal neutrons in $H_2O$ highly poisoned with B (nuclear absorption cross section follows the $1/\underline{v}$ law) and in $H_2O$ slightly poisoned with Cd (absorption cross section does not follow the $1/\underline{v}$ law) were measured. In the two cases, it was established that the diffusion length L for thermal neutrons decreases greatly with the increase of the absorber concentration in the $H_2O$. A linear variation of the values $1/L^2$ as a function of the relative concentration of the absorber was obtained, within the measurement limits, even for the case of very strong poisoning ($\Sigma$ (B) = 3.73 $\Sigma$ (H)). (tr-auth)

**32976** THE DIFFUSION CHARACTERISTICS OF A MODERATOR AS A FUNCTION OF TEMPERATURE. D. A. Kozhevnikov. At. Energ. (USSR), 14: 525-9(June 1963). (In Russian)

A summary of the experimental data on the diffusion length L and the diffusion coefficient D of thermal neutrons in water is presented. The variation of the diffusion length as a function of the temperature of the medium is given by the theoretical formula $L(T) = L(T_0)(T/T_0)^{0.25}$, but this formula becomes inaccurate at temperatures above 100°C. The general form for the analytical expression of the diffusion characteristics of a moderator as a function of temperature was found by writing the linear, integral-differential, transport equation, and by solving the transport equation with the use of spherical harmonics in the region of thermalization by a diffusion ($p_1$)-approximation. In a moderator where the absorption is weak (the lifetime is greater than the time of thermalization), the energy spectrum $f(\epsilon,T)$ is Maxwellian or close to it: $f(\epsilon,T) = [\epsilon/(kT)^2]$ $\exp(-\epsilon/kT)$. It was assumed that the transport cross section depends on the neutron energy and temperature of the moderator as follows: $\Sigma_{tr}(\epsilon,T) \sim \rho(T)\,\epsilon^{-\alpha}T^{\beta}$ where $\alpha \geq 0$, and $\beta > 0$. The absorption cross section followed a 1/v relation. The final formula is given as follows: $L(T) = L(T_0)[\rho_0/\rho(T)](T/T_0)^{(2\alpha-2\beta+1)/4}$. This formula is in good agreement with the available experimental data on the diffusion length of thermal neutrons in water at various temperatures. (TTT)

**32977** A BEAM OF POLARIZED NEUTRONS OBTAINED BY REFLECTION FROM A MAGNETIZED COBALT MIRROR. J. Kopecky, B. Chalupa, R. Michalec, and J. Kajfosz (Inst. of Nuclear Research, Czechoslovak Academy of Sciences, Rez). Czech. J. Phys., 13: 474-6(1963). (In Russian)

An efficient method for obtaining a beam of polarized neutrons by reflection from a magnetized cobalt mirror is discussed. The incident beam of thermal neutrons is formed by a collimator with a maximum angle of deviation of 12 min. The degree of polarization was determined by reflecting the beam from a second cobalt mirror. The degree of polarization was (94 ± 2) % and the flux of the polarized neutrons was $3 \times 10^5$ n $cm^{-2}$ $sec^{-1}$. The experimental apparatus was illustrated. (C.E.S.)

**32978** FORMATION OF NEUTRON BEAMS WITH SPECIAL PROPERTIES. K. H. Beckurts, P. A. Egelstaff, H. Goldstein, and N. G. Sjoestrand. J. Nucl. Energy, Pt. A & B, 17: 147-51(July 1963).

Problems met in obtaining specific beams needed for various experiments are discussed. A list of desired beams (also neutron sources for shielding studies) is given, and approaches and problems in the production of each are outlined. (D.C.W.)

**32979** THE PRODUCTION OF MODERATED NEUTRON BEAMS FROM PULSED ACCELERATORS. A. Michaudon (CEN, Saclay, France). J. Nucl. Energy, Pt. A & B, 17: 165-86(July 1963).

The pulsed and moderated neutron beams, obtained from accelerators, must consist of bursts that are as intense and short as possible. The moderator brings about a loss in the neutron intensity and a distortion of the time distribution of the moderated neutrons. It is shown that for neutron time-of-flight spectrometers, the quality of a moderator can be defined by a "figure of merit". A study of the effects produced by a moderator and of its figure of merit, carried out by the Monte-Carlo method of calculation is presented. Some of the results are compared to theoretical results obtained by various authors who have used the Boltzmann transport equation with different approximations. Some practical considerations are discussed. (auth)

**32980** COLD NEUTRON SOURCES. F. J. Webb (Atomic Energy Research Establishment, Harwell, Berks, Eng.). J. Nucl. Energy, Pt. A & B, 17: 187-215(July 1963).

Experimental work on cold neutron source development is reviewed along with the theoretical explanations devised for the results obtained. Factors governing source design, the associated cryogenic and safety problems, large source design, and experiments by which source efficiency might be increased are also discussed. (D.C.W.)

**32981** THE USE OF NEUTRON OPTICAL DEVICES ON BEAM-HOLE EXPERIMENTS. H. Maier-Leibnitz and T. Springer (Technische Hochschule, Munich). J. Nucl. Energy, Pt. A & B, 17: 217-25(July 1963).

A survey is given on the applicability of neutron optical devices as an experimental tool for beam hole experiments at low energies, namely: plane or bent neutron reflecting mirrors, and straight or curved neutron reflecting beam tubes in which neutrons can be guided by multiple reflections. Advantages and uses of each device are given. The obtainable intensities are compared with more conventional means of the separation of slow neutrons from the background beam (diffraction crystals or filters). Two special applications, for small angle scattering and for capture $\gamma$-ray experiments, are discussed in more detail. (auth)

**32982** THE PERFORMANCE OF REFLECTING MULTI-CHANNEL COLLIMATORS AS A NEUTRON BEAM FILTER AND POLARIZER. H. B. Moeller, L. Passell, and F. Stecher-Rasmussen (Research Establishment, Risø, Denmark). J. Nucl. Energy, Pt. A & B, 17: 227-31(July 1963).

The results obtained to date from a study of the properties of reflecting multi-channel collimators are summarized. The measurements have not yet been completed but enough information is available to give an indication of the capabilities of the system. (auth)

**32983** THE EXACT SOLUTION OF SLOWING-DOWN EQUATION FOR FAST NEUTRONS. B. Kozik. Kernenergie, 6: 257-63(June 1963). (In German)

A means for the exact solution of stationary slowing-down equation for fast neutrons in an infinitely extended homogeneous medium for vanishing absorption and energy-independent anisotropy of the angular distribution in the center-of-mass system is given. (tr-auth)

**32984** MATHEMATICAL EXERCISES IN NUCLEAR ENGINEERING. G. Mardus. Kerntechnik, 5: 265-9(June 1963). (In German)

A homogeneous scattering medium with the shape of a parallelepiped and a circular cylinder is considered which contains in its center a point source of fast neutrons. Equations are derived from the old theories for the distribution of the retardation density for both shapes and of the thermal flux for the parallelepiped. (D.L.C.)

**32985** ON THE QUASI-ELASTIC MAGNETIC SCATTERING OF SLOW NEUTRONS. Th. W. Ruijgrok (Rijksuniversiteit, Utrecht). Physica, 29: 617-30(June 1963). (In English)

It is shown that the imaginary part of the spin correlation function can be interpreted as the function which describes the propagation of a disturbance in the magnetization. This is a generalization of Van Hove's work for a gas or liquid. Assuming that for large times the imaginary part of the spin correlation function satisfies a wave equation with damping and using Schofield's relation between the real and imaginary part of this function, the line form for quasi-elastically scattered neutrons is calculated. The quasi-elastic scattering by a liquid is discussed. (auth)

**32986** NEUTRON SCATTERING BY MOLECULAR SYSTEMS. Jerzy A. Janik (Jagiellon Univ., Krakow and Inst. of Nuclear Physics, Polish Academy of Sciences, Krakow). Postepy Fiz., 14: 167-90(1963). (In Polish)

The field of scattering of slow neutrons by hydrogenous compounds of a variety of molecular structures is reviewed. The compounds that comprise the molecular systems covered are discussed separately according to the categories solids, liquids, and gases. Experimental and theoretical determinations of neutron scattering cross sections include total cross sections, differential angular cross sections, and double-differential energy and angular cross sections. The neutron energy region that is treated ranges from tens of milli-electron volts to tens of electron volts, the region of importance from the point of view of molecular binding and excitation of the rotational and vibrational levels of the molecular structure. The salient features of the theoretical background are given, followed by a discussion of experimental methods of measurement. A comparison of theory and measurement for gas molecules, molecular systems in liquids, and molecular systems in solids is discussed. (TTT)

**32987** THE THEORY OF SLOW NEUTRON SCATTERING IN MAGNETIC CRYSTALS. Yu. A. Izyumov. Usp. Fiz. Nauk, 80: 41-92(May 1963). (In Russian)

The theory of slow neutron scattering was reviewed considering inelastic and critical scattering and polarization. The analysis is presented as a unified mathematical scheme corresponding to the Born approximation. By introducing the provisional Van Hove formalism, the problem of calculating scattering cross sections as solid angle and energy range units is reduced to a calculation of the Fourier component correlating the position of two atoms in the lattice at various moments of nuclear scattering and spin projection correlations for magnetic scattering. The mathematical apparatus for calculating various problems in the theory of scattering is given in the first chapter. The second chapter deals with elastic nuclear and magnetic scattering and the basis of structural neutronography. The third chapter is devoted to inelastic neutron scattering and single quantum scattering with an absorption or emission of only one phonon or magnon. The fourth chapter describes the properties of magnetic neutron scattering near the Curie point, and the fifth is concerned with polarized neutron scattering cross sections and variations of incident neutron beam polarization vectors. (R.V.J.)

**32988** THE CALCULATION OF FAST-NEUTRON ATTENUATION PROBABILITIES THROUGH A NINE-INCH POLYETHYLENE SLAB AND COMPARISON WITH EXPERIMENTAL DATA. L. G. Mooney (General Dynamics, Fort Worth, Tex.). 14p. (CONF-39-19; FZM-2936)

From American Nuclear Society Meeting, Salt Lake City, June 1963.

Calculations of neutron penetration probabilities were performed to evaluate the Monte Carlo Multilayer Slab Penetration Procedure. A 9-in. polyethylene slab was chosen for the calculations and results were compared with experimental data. The calculated and measured dose rates agree within 20% for all exit polar angles. The calculations indicate that incident neutrons with energies less than 2.5 Mev do not contribute significantly to the transmitted dose rate. (auth)

**32989** STUDIES OF NEUTRON MODERATION IN ICE WITH A TEMPERATURE OF 90°K USING ACTIVATION METHODS. W. Maenner. Thesis, Munich, Technische Hochschule, 1961. 46p. $2.00.

At temperatures of 90 and 273°K effective neutron temperatures of 215 and 335°K, respectively, were observed. The ratio of neutron densities for these two temperatures is 1.20. This value is in agreement with theoretical predictions. The influences of absorption and finiteness of the moderator are discussed. The cold neutron gain produced by cooling from 273 to 90°K is 2.4. (Gmelin Inst.)

**32990** VOPROSY NEITRONNOI FIZIKI SREDNIKH ENERGII (Problems in Neutron Physics of Intermediate Energies). M. V. Pasechnik. Kiev, Izdatel'stvo Akademii Nauk Ukraiuskoi SSR, 1962. 336p.

A compilation is given of available experimental and theoretical data on reactions of intermediate-energy neutrons with nuclei. Problems of neutron physics are analyzed, and data on nuclear constants useful for designing and calculating nuclear reactors are included. 173 references. (R.V.J.)

## Nuclear Properties and Reactions

*Refer also to abstracts 31797 and 32294.*

**32991** (ANL-6727) FAST NEUTRON SCATTERING FROM $Ta^{181}$. A. B. Smith (Argonne National Lab., Ill.). May 1963. Contract W-31-109-eng-38. 17p.

The spectrum of neutrons scattered from $Ta^{181}$ was

measured at incident neutron energies ranging from 0.3 to 1.5 Mev. Time-of-flight techniques were employed to resolve the elastically and the inelastically scattered components. The angular distribution of the elastically scattered neutrons was measured at $\lesssim$50-kev intervals with an incident spread of neutron energy of ~20 kev. Inelastically scattered neutron groups resulting in the excitation of residual nuclear levels at 140 ± 10, 300 ± 10, 620 ± 20, 725 ± 25, 900 ± 30, and 980 ± 30 kev were observed. The measurements indicated that the levels at 725 and 980 kev were composed of two or more components. In addition, inelastic scattering to a 480 ± 20-kev level was tentatively observed. The magnitudes of the differential elastic cross sections and of the inelastic excitation functions were determined relative to the known elastic scattering cross section of carbon. The experimental results were compared with those obtained in previous measurements and a qualitative comparison was made with theoretical calculations. (auth)

**32992** (AWRE-0-59/63) AN INTERCOMPARISON OF THE DETERMINATION OF Pu-239, Pu-238 AND Pu-236 BY $\alpha$ COUNTING TECHNIQUES IN THE UK, USA AND CANADA. D. E. Watt, R. L. G. Keith, and F. Brown (United Kingdom Atomic Energy Authority. Weapons Group. Atomic Weapons Research Establishment, Aldermaston, Berks, England). July 1963. 12p.

Good agreement was obtained between laboratories in the UK, USA, and Canada when the $\alpha$ activities of $Pu^{238}$ and $Pu^{239}$ sources were intercompared. Measurements on solutions of $Pu^{238}$ and $Pu^{239}$ showed that solution storage and source preparation techniques could lead to a spread of up to 2% in the results. Alpha pulse analyses of mixed $Pu^{236}$, $Pu^{238}$, and $Pu^{239}$ sources gave a spread in results for peak ratios of $Pu^{238}$ : $Pu^{239}$ of 2.7% for thin sources and 3.8% for thick sources. Anomalous results for the counting and pulse analysis of $Pu^{236}$ indicated that further work on this isotope is required. (auth)

**32993** (BNL-6955) THE SCATTERING OF $He^3$ BY ALPHA PARTICLES. Y. C. Tang (Brookhaven National Lab., Upton, N. Y.); E. Schmid, and K. Wildermuth (Florida State Univ., Tallahassee). [1962]. Contract [AT(30-2)-Gen-16]. 38p. (CONF-22-10)

From American Physical Society Meeting, New York, January 1963.

The elastic scattering of $He^3$ by alpha particles in the energy range 0 to 20 Mev was considered using the method of resonating-group structure in the one-channel approximation. A two-body, central potential of Gaussian form which fits the low-energy nucleon-nucleon scattering data as well as possible was used. Saturation was taken approximately into account by choosing the radii of the clusters according to the experimental data. Phase shifts were computed up to $l = 6$. The presence of a $l = 3$ resonance was predicted with an excitation energy of about 6 Mev. Angular distributions at 1.7 and 16.6 Mev in the center-of-mass system were also calculated. At 1.7 Mev, the theoretical result agreed very well with the experimental data. At 16.6 Mev, the calculation predicted correctly the position of the diffraction minima and maxima, but the differential cross sections were somewhat larger than the experimental values in the forward angular region. An optical model analysis was also performed at these two energies. It was found that at the higher energy, an imaginary optical potential of about 2 Mev is necessary to obtain the best fit with experiment. This indicated that in the resonating-group calculation, channels other than the $He^3$-$\alpha$ channel are also important in determining the elastic scattering cross section at relatively high energies. Specifically, it can be shown from the existing reaction data that the other important channels are the p-$Li^6$ channels with $Li^6$ in the ground and the first excited state. Calculations were also done with a second two-body potential which was extensively used in resonating-group calculations by other people. (auth)

**32994** (CONF-39-37) COMMENTS ON ENERGY DIFFERENTIAL NEUTRON CROSS SECTIONS AS APPLIED TO REACTOR PHYSICS. R. G. Fluharty (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). [nd]. Contract [AT(10-1)-205]. 3p.

From American Nuclear Society Meeting, Salt Lake City, June 1963.

The nature of the corrections that must be made to nuclear cross sections if their dependence in not purely $1/v$ is discussed. Particular emphasis is placed on the necessity of such corrections if a comparison of cross sections (absorption, etc) or a quantity dependent thereon is to be made at a particular velocity. (D.C.W.)

**32995** (CONF-46-44) PRECISE KINETIC ENERGY MEASUREMENTS AND FINE STRUCTURE IN THE SPONTANEOUS FISSION OF $Cf^{252}$. J. S. Fraser, J. C. D. Milton (Atomic Energy of Canada Ltd. Chalk River Nuclear Labs., Chalk River, Ont.); H. R. Bowman, and S. G. Thompson (California. Univ., Berkeley. Lawrence Radiation Lab.). [nd]. Contract W-7405-eng-48. 10p.

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

The kinetic energy distribution of fragments from the spontaneous fission of $Cf^{252}$ was obtained by time-of-flight techniques. Peak values of 79.8 and 105.9 Mev were observed, and the individual curves are nearly gaussian. The mean values agree within 1% with the results of Whetstone. A fine structure in the fragment yields, similar to that in the slow neutron fission of $U^{235}$, was also observed. The structure seems to be a feature of fission for moderate excitation energies and is essentially due to the pairing energy of the even-even fragments that produces local variations of the yield through the level density factors of the partial fission widths. (D.C.W.)

**32996** (CONF-46-78) POLARIZATION OF NEUTRONS FROM THE D(d,n)$He^3$ REACTION. J. T. Rogers and C. D. Bond (Virginia Polytechnic Inst., Blacksburg). [nd]. Contract [AT(40-1)-2726]. 13p.

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Deuterons were directed against $D_2O$ vapor deposited on the walls of a target Dewar of liquid air. The polarization of the neutrons was determined by observing the right-left asymmetry in scattering from carbon of known polarization. Values of 11.1 (maximum), 7.8, and 6.0% were found at 99, 81.5, and 67.5 kev, respectively. The carbon polarization is also shown, and these results are compared with other determinations and with theory. (D.C.W.)

**32997** (CONF-46-79) TRITON-INDUCED REACTIONS ON $B^{10}$. H. D. Holmgren (Naval Research Lab., Washington, D. C. and Maryland. Univ., College Park); L. M. Cameron and R. L. Johnston (Naval Research Lab., Washington, D. C.). Mar. 1963. Contract AT(40-1)-2098. 46p.

From American Physical Society Meeting, Washington, D. C., April 1963.

The differential cross sections were studied as functions of angle and bombarding energies for the $B^{10}(t,p)B^{12}$ reactions leading to the ground and 0.95-, 3.39-, and 3.75-Mev states of $B^{12}$; for the $B^{10}(t,d)B^{11}$ reactions leading to the

ground and 2.14-Mev states of $B^{11}$; and for the $B^{10}(t,\alpha)Be^{9}$ reactions leading to the ground and 2.430- and 3.04-Mev states of $Be^{9}$. The total cross sections for these reactions at 1.950 Mev were obtained by numerical integration of differential cross sections and are 6.4, 8.0, 6.8, and 5.6; 35 and 16; and 12, 24, and 10 mb, respectively. The differential cross sections for all groups exhibit very smooth energy dependences and the total cross sections appear to approach essentially constant values in the vicinity of Coulomb barrier. The angular distributions of the ground state deuteron group were fitted with plane wave calculations including stripping and heavy-particle stripping. The energy dependence of the angular distribution of the ground-state $\alpha$-particle group suggests that the $B^{10}(t,\alpha)Be^{9}$ reaction proceeds, to some extent, by a pickup interaction. Possible mechanisms for the other reactions are also discussed. 28 references. (auth)

**32998** (CONF-52-3) ATOMIC EFFECTS ON NUCLEAR REACTION YIELD CURVES. R. G. Herb (Wisconsin. Univ., Madison). [1963]. Contract [AT(11-1)-Gen-7]. 22p.

From the International Conference on Nuclidic Masses, IAEA, Vienna, Austria, July 1963.

The Lewis Effect (peak above the resonance) in resonance yield curves is discussed. Attempts at explaining the observed curves are reviewed, and experimental and theoretical curves for $Al^{27}(p,\gamma)Si^{28}$ and $Ni^{58}(p,\gamma)Cu^{59}$ are compared. Effects of contaminants on the curves are considered. Satisfactory reproducibility has been achieved in obtaining experimental curves, and good agreement between calculated and experimental curves is noted. (D.C.W.)

**32999** (CONF-62-7) HICH ANGULAR MOMENTUM CUT-OFF IN NUCLEAR LEVEL DENSITIES. Donald W. Lang (Bartol Research Foundation, Swarthmore, Penna.). [1963]. Contract AT(30-1)-1679. 9p.

From Third Conference on Reactions Between Complex Nuclei, Asilomar, Calif., Apr. 1963.

Gamma radiation emitted by compound nuclei formed in heavy ion bombardment has proved experimentally to be predominantly quadrupole rather than dipole as expected from theory. An attempt is made to describe the experimental results by a theory in which nuclear states for the dipole transitions are missing. Inclusion of an $M^4$ term, where M is the angular momentum of a state, in the distribution of states is shown to lead to fewer states at high momentum. A form that excludes states beyond a certain high momentum is included. (D.C.W.)

**33000** (CONF-67-15) CROSS SECTION OF COPPER-63 FOR NUCLEAR ACCIDENT DOSIMETRY. Lowell L. Anderson (Argonne National Lab., Ill.). [1963]. Contract W-31-109-eng-38. 25p.

From Health Physics Society Annual Meeting, New York, New York, June 1963.

Nuclear accident dosimeter systems employing cadmium-covered copper foils to measure neutron flux in the intermediate energy region have, in the past, used unlikely assumptions about the variation with energy of both activation cross section and differential flux. It is suggested here that the average cross section used be based on the resonance activation integral. This procedure implies a 1/E flux assumption. The activation integral of copper-63 was measured, and the results are compared here with measurements by others. A working value of 4.2 barns, corresponding to 30 mil cadmium covers, was adopted for the effective resonance integral. The efficiency of $2\pi$ beta counters for 5 mil copper foils was found to be 6.9%. These parameters allow a flux calculation that is shown to be relatively insensitive to departures from a 1/E flux if the flux per log E may be represented as a linear function of log E. It is proposed, also, that activation data from cadmium-covered indium be used in conjunction with that from copper for a two-point determination of flux per log E. (auth)

**33001** (CONF-128-1) ENERGY LEVELS IN A SQUARE WELL WITH HARD CORE. R. L. Hoover, E. Merzbacher (North Carolina. Univ., Chapel Hill); and J. E. Rives (Duke Univ., Durham, N. C.). [nd]. Contract [AT(40-1)-2408]. 9p.

From American Physical Society Meeting, Tallahasee, Apr. 1963.

Target nuclei differing only by the presence of two neutrons may display neutron resonance levels in the kev region at the same energies. The ability of a model involving a spherical square well with an infinitely hard spherical core to account for such behavior is examined. (D.C.W.)

**33002** (NEVIS-116) MUON CAPTURE IN HYDROGEN (thesis). Joseph E. Rothberg (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). June 1963. Contract Nonr-266(72). 150p. (AD-409501)

The muon capture rate in liquid hydrogen was measured by scintillation counter techniques. The experiment tests muon-electron universality in interaction with a proton at a momentum transfer of 100 Mev/c. The use of ultra-pure liquid hydrogen, a purified muon beam, neutron-gamma ray discriminating detectors and oscilloscope photography made possible the detection of the 5.2-Mev neutron from the relatively improbable capture reaction ($\mu^- + p \rightarrow n + \nu$). Observation of the well known pion capture reaction ($\pi^- + p \rightarrow n + \gamma$) served as a check on many aspects of the experimental arrangement as well as on the neutron detector efficiency calculation. Interpretation of the muon capture experiment depends on knowledge of the muon molecular wave function and the muon-proton spin configuration; these are known from detailed calculations. The muon molecular formation rate was measured in an independent experiment, but the present result is relatively insensitive to it. The stability of the muon molecular ortho state against transitions to the para ground state for times comparable to the free muon lifetime is confirmed. The experimental result of the capture rate measurement, $464 \pm 42$ $sec^{-1}$ is compared with $562 \pm 60$ $sec^{-1}$, the rate expected on the basis of the conserved vector current theory, muon-electron universality and the accepted value of the "induced pseudo-scalar" coupling constant. 42 references. (auth)

**33003** (NEVIS-117) MUONIC MOLECULES IN LIQUID HYDROGEN. Edward J. Bleser (Columbia Univ., Irvington-on-Hudson, N. Y. Nevis Labs.). June 1963. Contract Nonr-266(72). 98p.

The yield and time distribution of 5.5-Mev gamma rays from the fusion reaction $p + d \rightarrow He^3 + \gamma$ were studied. The reaction was catalyzed by muons from the Nevis Synchrocyclotron which were stopped in a target containing high purity liquid hydrogen. A digitron of 30 nsec resolving time was used to study the yield of gamma rays as a function of the time that elapsed between the stopping of a muon and the emission of a gamma ray and as a function of the deuterium concentration, which was varied from 1 ppm to 25%. Analysis of the experimental distributions gave rates for the following muonic molecular processes: $p\mu + p \rightarrow p\mu p$, $\lambda_{pp} = (1.89 \pm 0.10) \times 10^6$ $sec^{-1}$; $p\mu + d \rightarrow d\mu + p$, $\lambda_e = (1.48 \pm 0.13) \times 10^{10}$ $sec^{-1}$; $d\mu + p \rightarrow p\mu d$, $\lambda_{pd} = (5.8 \pm 0.3) \times 10^6$ $sec^{-1}$; and $p\mu d \rightarrow He^3 + \gamma$, $\lambda_f = (0.305 \pm 0.010) \times 10^6$ $sec^{-1}$. (The presence of the $\mu$ indicates a muonic molecule.) The yield of fusion gamma rays increased with increasing deuterium concentration until it reached a satura-

tion value of (14.0 ± 2.4)% at 1% concentration. At 25% deuterium concentration the yield increased by a factor of 1.17 ± 0.01 above the saturation yield. This effect agreed with a prediction by Wolfenstein and Gershtein. When Ne was in solution in the H at a concentration of 1%, all of the muons transferred to the Ne; and the disappearance rate of muons bound to Ne was measured to be (0.658 ± 0.010) × $10^6$ $sec^{-1}$. (auth)

**33004** (NP-12986) MIXING OF T = 0 AND T = 1 STATES IN THE GIANT RESONANCE REGION OF $O^{16}$. Technical Report No. 311. Walter Greiner (Maryland. Univ., College Park). Feb. 1963. 14p.

The mixing of T = 0 and T = 1 collective states in the giant resonance region of $O^{16}$ is discussed. The quantitative investigation is based on the wave functions of Gillet. The experimentally observed bump at the left-hand side of the (γ-n) cross section of the giant resonance in $O^{16}$ is explained theoretically due to admixing a T = 0 state to the giant resonance. (auth)

**33005** (ORNL-TM-636) NUCLEAR CROSS SECTION PROGRAM AT ORNL, FEBRUARY 15, 1963–AUGUST 1, 1963. H. B. Willard (Oak Ridge National Lab., Tenn.). Aug. 1, 1963. Contract W-7405-eng-26. 21p.

The nuclear cross section activities at ORNL for the period February 15, 1963 through August 1, 1963 are reviewed. Reactions, scattering, and the effects thereof were examined. (auth)

**33006** (UCRL-7192) SCATTERING OF 14-Mev NEUTRONS FROM NITROGEN AND OXYGEN. R. W. Bauer, J. D. Anderson, and L. J. Christensen (California. Univ., Livermore. Lawrence Radiation Lab.). Feb. 27, 1963. Contract W-7405-eng-48. 20p. (CONF-46-8)

From American Physical Society Meeting, Washington, D. C., April 1963.

The differential cross sections for elastic scattering of 14-Mev neutrons from nitrogen and oxygen were measured in the angular range from 17 to 140°, using liquid targets and annular ring geometry. Inelastic scattering to the 2.31- and 3.95-Mev levels in $N^{14}$ and to the levels near 6 and 7 Mev in $O^{16}$ was investigated over a more restricted angular range. The 2.31-Mev level in $N^{14}$ was not excited appreciably, in disagreement with previously reported results. For both elements, the elastic scattering cross sections (determined to an accuracy of 10%) were found to be appreciably higher than the optical model predictions by Bjorklund and Fernbach for scattering angles larger than 70°. The inelastic cross sections measured are, within experimental accuracy, the same as the corresponding (p,p′) cross sections. (auth)

**33007** (UCRL-7297) THE ELECTRIC QUADRUPOLE MOMENT OF THE 35-kev STATE OF $Te^{125}$. C. E. Violet, Rex Booth, and F. Wooten (California. Univ., Livermore. Lawrence Radiation Lab.). Apr. 4, 1963. Contract W-7405-eng-48. 13p. (CONF-23-15)

From American Physical Society Meeting, St. Louis, Mo., March 1963.

Quadrupole interaction of $Te^{125}$ in Te was studied using the Mössbauer resonance of the $Te^{125}$ 35.6-kev transition. Initial measurements were improved by using a single-line source prepared by diffusing $I^{125}$ into Cu. With this source at 82°K, resonant-absorption spectra were measured for polycrystalline Te absorbers at 82° and 4.2°K. The splitting at both temperatures is 0.76 ± 0.02 cm/sec or ΔE = (9.0 ± 0.2) × $10^{-7}$ ev. The quadrupole splitting for spin $^3/_2$ is $\Delta E = \frac{1}{2}\, eq\, Q\, (1 + \frac{1}{3}\eta^2)^{1/2}$. |Q| is estimated from the measured splitting and a semiempirical determination of the field gradient q and the asymmetry parameter η. The quadrupole moment of $Te^{125}$ is then found to be $|Q| = (0.20^{+0.03}_{-0.02}) \times 10^{-24}$ $cm^2$. (auth)

**33008** (ZFK-PHA-8) ZUM ZERFALL DES $Tm^{169}$. (The Decay of $Tm^{169}$). Lothar Funke, Karl-Heinz Kaun, Guenther Mueller, Horst Sodan, and Lothar Werner (Germany. Zentralinstitut für Kernphysik, Dresden). Jan. 1963. 12p.

Preliminary results of measurements of conversion electrons and γ–γ coincidences in the decay of $Tm^{169}$ produced by α irradiation of $Ho^{165}$ with the Rossendorf-cyclotron are given. (auth)

**33009** (UCRL-Trans-978) RESULTS OF CALCULATIONS OF NUCLEAR FISSION ACCORDING TO A LIQUID-DROP MODEL. V. M. Strutinskii (Akademiya Nauk S.S.S.R. Ordena Lenina Institut Atomnoi Energii). Translated for Univ. of California Lawrence Radiation Lab., Berkeley. 1963. 45p.

An iteration method was used to calculate asymmetrical and symmetrical equilibrium shapes of nuclei in liquid-drop models with variable surface tension. Nonequilibrium shapes were also calculated to analyze the stability of equilibrium symmetrical solutions with respect to asymmetrical surface variations. The results are described and examined in the light of experimental fission data, and the effectiveness of the iteration method is confirmed. (D.C.W.)

**33010** THE SHELL STRUCTURE AND THE ROCHE NUCLEAR DENSITY. Gh. T. Jeverdan and Gh. Ilie Rusu. Acad. Rep. Populare Romine, Filiala Iasi, Studii Cercetari Stiint., Fiz. Stiinte Tehn., 13: 173-88(1962). (In Rumanian)

The form of the wave eigen-functions and the energy levels of neutrons and protons for nuclei with nonhomogeneous distribution of neutrons and protons of the Roche type was given approximately. (tr-auth)

**33011** ISOTOPE SHIFT IN THE ULTRAVIOLET LINES OF Zn II. F. Leś and Z. Leś (Jagellonian Univ., Krakow). Acta Phys. Polon., 23: 795-800(1963). (In English)

Isotope shift between $Zn^{64}$, $Zn^{66}$, and $Zn^{68}$ isotopes was investigated on the three ultraviolet lines of Zn II λ 2570.72 Å ($3d^9 4s^2\, ^2D_{5/2} - 3d^{10} 5p^2\, ^2P^0_{3/2}$), λ 2763.88 Å ($3d^9 4s^2\, ^2D_{3/2} - 3d^{10} 5p^2\, ^2P^0_{3/2}$) and λ 2782.83 Å ($3d^9 4s^2\, ^2D_{3/2} - 3d^{10} 5p^2\, ^2P^0_{1/2}$), using a Schüler type hollow cathode lamp cooled with liquid nitrogen and a Fabry-Perot interferometer with multi-layer dielectric and metallic-dielectric mirrors. In all three lines considerable isotope shifts were found, each amounting to about 115 mK between neighboring even isotopes. Accordingly, a new scheme of isotope shifts on the respective energy levels of Zn II is discussed. (auth)

**33012** SPIN ASSIGNMENTS IN EVEN–EVEN NUCLEI BETWEEN $O^{16}$ AND $Ca^{40}$. C. Broude and H. E. Gove (Atomic Energy of Canada Ltd., Chalk River, Ont.). Ann. Phys. (N. Y.), 23: 71-122(July 1963).

The assignment of spins to a number of levels in even-even nuclei from $O^{16}$ to $Ca^{40}$ by the measurement of gamma ray angular correlations following the excitation of the levels by inelastic scattering of protons is described. Coincidence gamma-gamma correlations were measured on the cascade from the excited state studied through the first excited state. Direct gamma ray correlations were also measured wherever possible to obtain additional information to ensure unique assignments. The highest level studies is at 6.44 Mev. All except one of the levels are stable against particle emission. No attempt was made to measure branching ratios. (C.E.S.)

**33013** RESONANCE AND DIRECT GAMMA RAY INTERACTIONS. L. Estrada (Universidad de Mexico) and H. Feshbach. Ann. Phys. (N. Y.), 23: 123-32(July 1963).

The results of the projection operator formalism for nuclear reactions are evaluated for gamma ray processes. A direct term and a resonance term in the Breit-Wigner form are obtained. The usual expression for the gamma ray width is found to be incomplete. One must also include the process in which the compound nucleus decays by particle emission but the latter radiates on the way out via the direct gamma ray interaction. The analogue of the Ward identity for many-body systems is derived. (auth)

**33014** ANGULAR DISTRIBUTION OF DEUTERONS IN THE REACTION ON $Li^6(\alpha,d_0)Be^8$ AT ENERGY OF 24 Mev. G. Demortier, J. B. Dossin, G. A. Savariraj, G. Deconninck (Université, Louvain, Belg.). Ann. Soc. Sci. Bruxelles, Ser. I, 77: 81-93(June 26, 1963). (In French)

The $Li^6(\alpha,d)$ reaction was investigated by the variable crystal thickness method. Angular distribution of deuterons leading to the ground-state of $Be^8$ was taken at 24.5 and 23.7 Mev $\alpha$-particle energies. The results show a strong structure that could be due to interference between KO and HPS mechanisms. (auth)

**33015** NOTE ON THE CHARACTER OF FIRST EXCITED STATES (2+) OF $Yb^{170}$, $Os^{186}$, AND $Os^{188}$. J. P. Deutsch, L. Grenacs, and P. Lipnik (Université, Louvain, Belg.). Ann. Soc. Sci. Bruxelles, Ser. I, 77: 94-7(June 26, 1963). (In French)

The conserved vector current theory of weak interactions applied to the analysis of the first-forbidden beta-decays (1−) → (2+) and (1−) → (0+) of $Tm^{170}$, $Re^{186}$, and $Re^{188}$ yields rather accurate values of the individual nuclear matrix elements involved in these transitions. It is shown that these values are in good agreement with a pure rotational excitation of the first-excited (2+)-states of the daughter-nuclei. (auth)

**33016** AN EMPIRICAL FORMULA FOR THE AVERAGE NUMBER OF FISSION NEUTRONS. L. D. Gordeeva and G. N. Smirenkin. At. Energ. (USSR), 14: 530-4(June 1963). (In Russian)

The "instantaneous" fission energy $E_F$, which is equal to the difference in energies between the fissioning nucleus and the fission fragments, is distributed between the kinetic energy of the fission fragments $E_K$ and the excitation energy $E_x$ of the fission fragments, which in turn is distributed between the prompt neutrons and prompt $\gamma$ quanta: $E_K + E_x = E_K + \nu E_\nu + E_\gamma$. Here, $\nu$ is the number of neutrons; $E_\nu$ is the average energy for the removal of a neutron from the fission fragment, and $E_\gamma$ is the total energy of the prompt $\gamma$ quanta. Within a narrow region of nuclei with Z = 90 to 100 and A = 230 to 250, the average number of neutrons $\bar{\nu}$ can be considered as a linear function of Z and A: $\bar{\nu} = C_1Z + C_2A + C_3$. Here, $C_1$, $C_2$ and $C_3$ are constants, and $C_3$ takes into account whether the nucleus is even or odd. Experimental data on the thermal neutron fission of the six odd nuclei $Th^{229}$, $U^{233}$, $U^{235}$, $Pu^{239}$, $Pu^{241}$, and $Am^{241}$ were used to derive the following empirical relation: $\bar{\nu}_T = 0.1894\ Z + 0.007\ A - 16.60 + \delta_\nu$. Here $\delta_\nu = (d\bar{\nu}/dE_n)\ \delta m \simeq 0.09\xi$ (where $\xi = \pm 1$ for the odd-odd, and even-even nuclei, and zero for nuclei with odd A). Values of $\bar{\nu}_T$ were computed for the isotopes of Th, Pa, U, Np, Pu, Am, and Cm, and agree within 3% when compared with known experimental values of $\bar{\nu}_T$. (TTT)

**33017** THE NEUTRON YIELD FROM A NUMBER OF MATERIALS SUBJECTED TO IRRADIATION WITH $\alpha$-PARTICLES OF RADON AND ITS DECAY PRODUCTS. G. V. Gorshkov, V. A. Zyabkin, and O. S. Tsvetkov. At. Energ. (USSR), 14: 544-9(June 1963). (In Russian)

The energies and reaction thresholds in Mev were computed from the corresponding mass defect for an ($\alpha$, n) reaction on the light isotopes of Li, Be, B, C, N, O, F, Na, Mg, Al, Si, P, S, and Cl. The neutron yield was determined by placing the compound or ore in an ampoule, and then, filling the ampoule with radon gas. A paraffin reflector was used to increase the neutron count rate by the boron detector. A 5 cm lead filter was used to reduce the gamma background. The neutron counting efficiency was determined as a function of the neutron energy. Since a 15% moisture content reduced the neutron yield by 14%, all samples were dried for 1 to 2 hours at 100 to 150°C before counting. Neutron yields were determined on Be, BeO, B, $H_3BO_3$, Al, $Al_2O_3$, Mg, MgO, $CaF_2$, F, $CaCl_2$, Cl, NaF, NaCl, Na, LiOH, Li, $SiO_2$, Si, O, C, and S. Corrections were made for the variation in neutron energy. The average neutron energy is approximately equal to the following: $\bar{E}_n = \Sigma_{k=1}^{n} \alpha_k \bar{E}_{Nk}$. Here, n is the number of element in a given compound, $\alpha_k$ is the relative contribution from the k-th element to the total neutron yield, and $E_{Nk}$ is the average neutron energy for the k-th element. The neutron yield depends on the atom percent of an element in a mixture and the relative stopping power of each element. The measured neutron yields for ores such as fluorite, granite, schale, glauconite, monazite, marble, and uranium ores are in most cases in good agreement with the values calculated from the neutron yields on the individual chemical elements in the ore. The neutron yields are determined mainly by the Al, Si, O, and Na content in the ore. (TTT)

**33018** THE NEUTRON YIELD FROM AN ($\alpha$,n) REACTION ON Be, B, C, O, F, Na, Mg, Al AND Si SUBJECTED TO IRRADIATION WITH $\alpha$-PARTICLES FROM THORIUM, URANIUM, AND THEIR DECAY PRODUCTS. G. V. Gorshkov and O. S. Tsvetkov. At. Energ. (USSR), 14: 550-4(June 1963). (In Russian)

The neutron yield was determined on a mixture of $ThO_2$ and Be, BeO, Al, $Al_2O_3$, or MgO, and on a mixture of a uranium preparation containing 29.5% uranium and ~35% $SiO_2$ with BeO, $Al_2O_3$, MgO, B, and Al. Since the neutron count rates were so low (about 0.5 to 10 neutrons/sec-4$\pi$), all the measurements were carried out in an underground installation at a depth equivalent to 200 m water equivalent. The sensitivity of the slow neutron scintillation counter was 0.05 neutrons/sec-4$\pi$. The particle size was 2 to 5 microns. The neutron yield depended on the weight composition of the source and on the relative stopping power of the elements in the source. The maximum neutron yield from a thick target is given by the following relation: $Q_0 = kE^n$. Here, k and n are constants, and E is the energy of the alpha particle. Values of k and n are given for Be, B, C, F, Mg, Al, and Si. The maximum neutron yield of a Ra−Be source was found to be $1.8 \times 10^7$ neutrons/sec-curie of radium (without polonium) which compares well with an experimental value of $1.7 \times 10^7$ neutrons/sec-curie for a freshly-prepared Ra−Be source. The calculated neutron yields are in good agreement with experimental neutron yields reported in the literature for RaTh + Be, $Ac^{227}$ + Be, and Pu + Be sources. (TTT)

**33019** THE COMPARATIVE CHARACTERISTICS OF TERNARY FISSION IN URANIUM AND PLUTONIUM. V. N. Dmitriev, L. V. Drapchinskii, K. A. Petrzhak, and Yu. F. Romanov. At. Energ. (USSR), 14: 574-5(June 1963). (In Russian)

Data were accumulated on a total of 20,000 ternary fission events for the slow neutron fission of $U^{233}$, 15,000 ternary fission events for $U^{235}$, and 12,000 fission events for $Pu^{239}$. The sum of the energies of the fission fragments $E_1 + E_2$ was plotted as a function of $E_1/E_2$ for double and ternary fission on contour diagrams, where the individual curves indicated the relative fission frequency. The contour lines for double and ternary fission are very similar in appearance, even though the energy of the fission fragments from ternary fission is about 15 Mev lower than from double fission. The contour curves show that ternary fission, like binary fission, is asymmetric. In the ternary fission of $U^{233}$, there was a slight tendency towards a higher yield of elements of lower mass. The decrease in energy of the light fission fragments $\Delta E_L$ was about 8.8 Mev for the ternary fission of $U^{233}$, $U^{235}$, and $Pu^{239}$. The decrease in energy of the heavy fission fragments $\Delta E_H$ was 8.3 Mev for the ternary fission of $Pu^{239}$, and 6.3 Mev for the ternary fission of $U^{233}$ and $U^{235}$. The results indicated that the nature of ternary fission is very similar for $U^{233}$, $U^{235}$, and $Pu^{239}$. (TTT)

**33020** THE TERNARY FISSION OF $U^{235}$ WITH 14-Mev NEUTRONS. N. A. Perfilov, Z. I. Solov'eva, and R. A. Filov. At. Energ. (USSR), 14: 575-7(June 1963). (In Russian)

A photographic plate steeped in a uranium salt containing 92.8% $U^{235}$ was irradiated with 14-Mev neutrons obtained from a t(d,n)$He^4$ reaction. The plate was placed in a hollow cadmium cylinder containing a charge of boron in order to reduce the thermal neutron background. The total number of binary and ternary fissions was determined by a microscopic scan of the photographic plate. Only long-range $\alpha$ particles with a path-length of at least 30 microns were counted as ternary fissions. A total of 65 ternary fissions were detected from about 100,000 binary fissions. After correcting for ternary fissions taking place on the surface of the emulsion or in the glass, the probability of ternary fission with respect to binary fission of $U^{235}$ was found to be 1:1350 ± 190 for 14-Mev neutrons. The angular and energy distributions of the fission $\alpha$ particles did not differ significantly for $U^{233}$, $U^{235}$, and $U^{238}$, and were independent of the energy of the incident neutron. The decrease in the probability of ternary fission with increasing neutron energy can be explained by the formation of a compound nucleus with subsequent evaporation of a single neutron, and fission of the resulting excited nucleus. The data indicated that the probability of ternary fission in the uranium isotopes decreases monotonically with increasing mass. (TTT)

**33021** DETERMINING THE EFFECT OF CROSS-SECTION BLOCKING OVER THE WHOLE ENERGY REGION WITH ALLOWANCE FOR THE DOPPLER BROADENING OF A RESONANCE. L. P. Abagyan. At. Energ. (USSR), 14: 583-4(June 1963). (In Russian)

The blocking effect due to the resonance character of a capture cross section must be known as a function of the temperature of a medium ($T^0$,K), and as a function of the dilution of one element by other elements. The blocking coefficients for the capture cross section $f_c$, for the fission cross section $f_f$, for the scattering cross section $f_s$, and for the transport cross section $f_t$ were considered for $U^{238}$ as an illustrative case over an energy range of 6.68 ev to 1 kev, where the resonances are well resolved. It was assumed that the resonance parameters are $\Gamma_n^0 = 0.00176$, $\Gamma = 0.0246$, and D = 18.5 ev for the s-wave. The p-wave parameters were so chosen that the $U^{238}$ capture cross section would agree with the experimental data. The d-wave contribution is negligibly small. Consideration of the Doppler effect over the whole region of energies is a relatively simple matter because of the availability of tabulated temperature functions of $\eta_1$ (required for calculating the capture, scattering and fission cross sections), and of $\eta_2$ (required for calculating the transport cross section). The blocking coefficients are proportional to $\sqrt{T^0(K)}$ from 300 to 2100°K. The change in $f_c$ is plotted as a function of neutron energy at $\Gamma$ = 300°K for metallic $U^{238}$, and for $U^{238}$ diluted with a moderating element. The calculated values are in good agreement with the experimental values. (TTT)

**33022** NUCLEAR TRANSFER REACTIONS. [PART] IV. A. Gribaumont (Université Libre, Brussels). Bull. Classe Sci. Acad. Roy. Belg., Ser. 5, 48: 1344-9(1962). (In French)

The semi-classical treatment previously introduced in order to describe the single excitation or transfer nuclear reactions is extended to mutual excitations caused by direct excitation or double transfer. Selection rules were found for excitation without transfer. Mutual excitation reactions seem to involve both mechanisms. (auth)

**32023** NEUTRON-DEFICIENT ISOTOPES OF LANTHANUM — $La^{127}$, $La^{128}$, $La^{129}$, $La^{130}$, AND $La^{131}$. L. Yaffe (McGill Univ., Montreal), J. M. Alexander, and E. K. Hyde. Can. J. Chem., 41: 1951-5(Aug. 1963).

$La^{127}$, $La^{128}$, $La^{129}$, and $La^{131}$ were produced by the reaction of $C^{12}$ ions with Sb. Half lives of 3.5 ± 0.5, 4.6 ± 0.6, 8.6 ± 1.8, and 56 ± 3 min respectively, were obtained from the observed growth of the respective Ba daughters. The half life for $Ba^{128}$ was found to be 2.43 ± 0.05 days. $La^{129}$ and $La^{130}$ were produced and identified by the reactions $Ba^{130}$(p,2n) and $Ba^{130}$(p,n) respectively, carried out with targets enriched in $Ba^{130}$. In the proton bombardments, half lives of 10.0 ± 0.5 min and 8.7 ± 0.1 min were found for $La^{129}$ and $La^{130}$, respectively. (auth)

**33024** A STUDY OF $Cd^{115m,g}$ FORMED IN THE FISSION OF NATURAL URANIUM BY PROTONS OF ENERGIES 8 TO 60 Mev. R. S. Tilbury and L. Yaffe (McGill Univ., Montreal). Can. J. Chem., 41: 1956-60(Aug. 1963).

Excitation functions were measured for the formation of $Cd^{115m}$, $Cd^{115g}$, and $Ag^{115g}$ produced in the fission of natural U induced by protons of energies 8 to 60 Mev. The isomer yield ratio for $Cd^{115m,g}$ was found to increase with increasing proton bombarding energy over the range 20 to 60 Mev in contrast to published results for the deuteron fission of U, for which a minimum was found. (auth)

**33025** THE COBALT RESONANCE CAPTURE INTEGRAL. T. A. Eastwood and R. D. Werner (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Phys., 41: 1263-72(Aug. 1963). (AECL-1771)

The resonance integral of cobalt has been measured by comparison of the cadmium ratios for gold and cobalt in 1/E slowing-down spectra in two thermal reactors. The value obtained was 69.9 barns, for a cadmium cutoff of 0.5 ev, with the 1/v part included. The error, including uncertainties in the thermal neutron cross sections for cobalt and gold and the resonance integral for gold as well as the experimental error, is estimated to be ±3.5 barns. The reduced resonance integral, i.e., after subtraction of the 1/v part, is 53.1 ± 3.5 barns, and the $s\sqrt{(T_0/T)}$ value in the Westcott nomenclature is 1.60 ± 0.08. (auth)

**33026** THE REACTOR NEUTRON CAPTURE CROSS SECTION OF $Ag^{110m}$. R. G. Hart and R. L. Graham (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. J. Phys., 41: 1321-31(Aug. 1963). (AECL-1784)

Natural silver has been irradiated for 75.3 days in a

thermal neutron flux of $2.42 \times 10^{14}$ cm$^{-2}$ sec$^{-1}$, and the complex beta-ray spectrum of the resulting activities of 249-day $Ag^{110m}$ and 7.5-day $Ag^{111}$ have been studied with a magnetic spectrometer. From the measured ratio of the respective beta-ray intensities and using the currently accepted decay schemes of these nuclides a value of 82 ± 11 barns is obtained for the reactor neutron capture cross section of $Ag^{110m}$. Possible causes of systematic error are discussed. (auth)

**33027** THE MASS-FLOW FUNCTION OF NICKEL-62, SELENIUM-80, CADMIUM-114 AND TIN-118 ISOTOPES IN THE 50 TO 400 kev RANGE. E. A. Koltypin and G. B. Yan'kov. Dokl. Akad. Nauk SSSR, 150: 1263-6(June 21, 1963). (In Russian)

The mass-flow function, which is of great importance for nuclear models, may be determined in the tens and hundreds of kev range by the divergence of the transparency of the sample from the simple exponential attenuation as a function of the thickness. This was experimentally measured for $Ni^{62}$, $Se^{80}$, $Cd^{114}$, and $Sn^{118}$, the samples of which contained 90, 94, 95, and 70%, respectively, of the separated isotope. The study was limited to the 50- to 400-kev range and involved the comparison of the transparency of thick and thin samples, using the T(p,n)He reaction as the neutron source. The transparency of the samples was about 85%, that of the filters used about 25%. The tabulated results showed a low value at 181 kev for Ni, due probably to statistical fluctuations. For Se and Cd the mass-flow function was found to increase with increasing neutron energy; for Se its value at 92 kev was found to be $(1.42 \pm 0.33) \times 10^{-4}$; for Cd it was $0.5 \times 10^{-4}$. No p-wave resonance levels were found for $Sn^{118}$. (TTT)

**33028** GAMMA-GAMMA COINCIDENCES IN $Pd^{105}$. R. Bhattacharyya (Saha Inst. of Nuclear Physics, Calcutta). Indian J. Phys., 37: 209-14(Apr. 1963).

Gamma spectrum and gamma-gamma coincidence spectra measured with NaI(Tl) scintillation spectrometers reveal a 770-kev level and 420 and 390 kev gamma rays in $Pd^{105}$. A decay scheme, based on these results and the results previously obtained was proposed. These results are essentially in agreement with the recently reported work of Suter et al. (auth)

**33029** MEASUREMENT OF THE FISSION CROSS SECTION OF $U^{233}$ BETWEEN 1.7 AND 57 ev. H. Nifenecker, D. Paya, and J. Fagot (CEN, Saclay, France). J. Phys., 24: 254-8(Apr. 1963). (In French)

A xenon gas scintillation counter is used with one gram of $U^{233}$ to measure the fission cross section of $U^{233}$ for neutrons from 1.7 to 57 ev. The experimental apparatus and cross section curves obtained are presented. (auth)

**33030** RADIOCHEMICAL STUDIES ON URANIUM MULTIPLE FISSION. 5. FORMATION OF $Na^{22}$ IN NEUTRON FISSION OF $UF_4$. R. Muenze and G. Reinhard (Zentralinstitut für Kernphysik, Rossendorf, Ger.). Kernenergie, 6: 274-6(June 1963). (In German)

After the irradiation of $UF_4$ with thermal neutrons, the formation of $Na^{22}$ was detected. A determination of the activity showed that the most probable formation reaction can be regarded as $F^{19}(\alpha,N)Na^{22}$. The necessary fast alpha particles were produced by triple fission of $U^{235}$. (tr-auth)

**33031** STATISTICAL CONSIDERATIONS IN THE ANALYSIS OF DIRECTIONAL-CORRELATION DATA. C. W. Reich (Phillips Petroleum Co., Idaho Falls, Idaho); J. A. Merrill, and E. D. Klema. Nucl. Instr. Methods, 23: 36-44(May 1963). (In English)

The problem of the estimation of variances in directional-correlation experiments was studied. The results were obtained for, but the methods used are not limited to, correlation functions of the form $\alpha_0 + \alpha_2 P_2 (\cos\theta) + \alpha_4 P_4 (\cos\theta)$. Theoretical studies indicate that, for data taken at equally spaced angles, the relative magnitudes of the variances of $\alpha_2$ and $\alpha_4$ are independent of the coefficients of the particular correlation function. Furthermore, they vary in a systematic manner as the number of assumed angles is increased, the variance of $\alpha_4$ always being larger than that of $\alpha_2$. The results of a $2^k$-factorial experimental design study indicate that more precise estimates of the expansion coefficients than those yielded by the equally spaced angular configuration may be obtained if one restricts his observations to only three angles. The study provides these three angles and also predicts that one may vary the relative magnitudes of the variances of $\alpha_2$ and $\alpha_4$ by varying the relative frequency of observations at these three angles. While these studies are, for simplicity, based upon the assumption of observations having equal statistical weights, an extensive set of experimental data is presented which indicates that these ideas are essentially correct even when the statistical weights of the observations are quite unequal. A discussion of the accuracy, as contrasted with the precision, inherent in this technique of taking directional-correlation data is presented. The fact that the ratios obtained for $\alpha_\lambda/\alpha_0$ from a regression analysis are expected to differ from the "true," or theoretically calculated, coefficients of the $P_\lambda$ (cos $\theta$) terms was considered. It was shown that the differences between the two are negligible in the cases of interest here. These ideas may be extended to any experimental situation susceptible to a regression-type analysis. (auth)

**33032** A NANOSECOND NEUTRON TIME-OF-FLIGHT SYSTEM FOR THE HARWELL 30 Mev ELECTRON LINAC. F. W. K. Firk, J. K. Whittaker, E. M. Bowey, K. H. Lokan, and E. R. Rae (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Nucl. Instr. Methods, 23: 141-6 (May 1963). (In English)

The Harwell 30 Mev electron linear accelerator was modified to provide electron bursts of 10 nsec duration at a repetition rate of 250 pps and peak current 0.2 amp. A neutron time-of-flight spectrometer was set up to cover the neutron energy range from 0.5 Mev up to ~15 Mev. The timing system incorporates a 1000 channel analyzer, each channel having a duration of 4.3 nsec. Using a 20 meter flight path, a typical overall energy resolution of 40 kev at 2 Mev is achieved. Measurements of the energy spectra of photoneutrons from the reaction $S^{32}(\gamma,n)S^{31}$ when irradiated with 26 Mev bremsstrahlung demonstrate the performance of the spectrometer. (auth)

**33033** A NOTE ON ANGULAR DISTRIBUTION ANALYSIS. D. D. Watson, R. A. Moore, G. I. Harris, and L. W. Seagondollar (Univ. of Kansas, Lawrence). Nucl. Instr. Methods, 23: 157-8(May 1963). (In English)

A technique is given for calculating $\gamma$-ray angular distributions for (p$\gamma$) and (px$\gamma$) reactions. In the technique for the case of one mixing parameter $\delta_1$, the coefficients $A_k/A_0$ are plotted vs $y_1$ = arc tan $\delta_1$; the resulting curve is one cycle of a sine curve, and the maximum and minimum $A_k/A_0$ values are rapidly determined. For the case of two mixing parameters, $A_k/A_0$ can be expressed as a product of two sine curves. The extension of this technique to the case of three mixing parameters is also described. (D.L.C.)

**33034** THE POTENTIAL USE OF COMPTON SCATTERED GAMMA RAYS FOR NUCLEAR EXCITATION EXPERIMENTS. G. Baeckstroem (Inst. of Physics, Upp-

sala). Nucl. Instr. Methods, 23: 218-24(June 1963). (In English)

The possibility of using Compton-scattered radiation to induce nuclear resonance absorption is discussed. It is shown that sufficient counting rate may be obtained with available gamma sources if a suitably curved scatterer is used. The energy spread of the secondary radiation is investigated experimentally by comparison with monoenergetic gamma rays. The method seems promising for level life-times shorter than $10^{-13}$ sec. Energies up to 2.5 Mev may be produced, and possibly higher energies. (auth)

**33035** THE $^{1}H(t,n)^{3}He$ REACTION AS A NEUTRON SOURCE. W. Deuchars, J. L. Perkin, and R. Batchelor (Atomic Weapons Research Establishment, Aldermaston, Berks, Eng.). Nucl. Instr. Methods, 23: 305-8(June 1963). (In English)

The main characteristic of this reaction is that all the neutrons are emitted in the forward direction. Angular distributions of these neutrons for incident triton energies between 3.7 and 11.86 Mev are measured. In the forward direction the neutron flux obtainable is considerably greater than that from the bombardment of tritium by protons. This advantage is somewhat offset by the greater neutron energy variation with the angle of emission. The results of some measurements of the gamma rays from the Fe(n,n'γ) reaction are given to illustrate the possible uses of this neutron source. (auth)

**33036** STUDY OF NUCLEAR REACTIONS ON THE CYCLOTRON OF THE INSTITUTE OF PHYSICS OF THE UKRAINIAN ACADEMY OF SCIENCES. O. F. Nemets, M. V. Pasechnik, and N. N. Pucherov (Inst. of Physics, Kiev). Nucl. Phys., 45: 1-16(July 1963). (In English)

The main results of the experiments on the Kiev cyclotron are presented. The experiments include the study of (d,p) stripping reactions, elastic and inelastic scattering of protons and deuterons, proton polarization in elastic scattering and stripping reactions, and gross structure in the (d,p) reactions. (auth)

**33037** QUASI FREE ELECTRON SCATTERING IN THE IMPULSE APPROXIMATION. John Potter (Laboratoire de Physique Theorique, Orsay, France). Nucl. Phys., 45: 33-40(July 1963). (In English)

The reaction (e,e'p) in which electrons are scattered from nuclei and the outgoing electron and an ejected proton are detected in coincidence, is discussed. Jacob and Maris show that such reactions can provide detailed information on the energy levels and structures of the upper and lower shells of light and medium nuclei. They proposed an angular correlation experiment in terms of the angle made by the proton with the scattering plane of the electron. It is suggested that the same information can be obtained by performing experiments in the scattering plane, which is considerably simpler from the experimental point of view. Two types of experiments are suggested, namely angular correlation and energy sharing experiments. Formulas for the cross sections in the impulse approximation are given and curves are traced for the case of the s and p shells of $C^{12}$. (auth)

**33038** EXCITATION FUNCTIONS FOR $Li^{6}$ INDUCED REACTIONS ON $Au^{197}$. Carl E. Anderson, Martin Sachs, Inge-Maria Ladenbauer-Bellis, and Ivor L. Preiss (Yale Univ., New Haven). Nucl. Phys., 45: 41-8(July 1963). (In English)

The excitation functions for several nuclear reactions induced by $Li^{6}$ bombardments of $Au^{197}$ were measured in the energy range 15–40 Mev using stacked foils and radiochemical techniques. Reaction cross-sections were determined by absolute gamma-ray spectroscopy. The data indicate that the nucleides $Au^{196}$ and $Au^{198}$ are produced primarily by a single nucleon transfer. The data also suggest that $Hg^{197}$ and $Hg^{197m}$ are formed in part via surface reactions, while $Tl^{199}$, $Tl^{200}$, $Pb^{199}$, and $Pb^{200}$ are produced by a compound nucleus mechanism. (auth)

**33039** A HINDERED E2 GROUND STATE TRANSITION IN $Po^{207}$. G. Astner, I. Bergstroem, L. Eriksson, U. Faegerquist, G. Holm, and A. Persson (Nobel Inst. of Physics, Stockholm and Royal Inst. of Tech., Stockholm). Nucl. Phys., 45: 49-53(July 1963). (In English)

The half life of the 69-kev first excited state in $Po^{207}$ was determined to be 205 ± 10 ns using a time-to-pulse-height converter to measure alpha-electron delayed coincidences. The 69-kev E2 ground state transition, interpreted as $p_{1/2} \rightarrow f_{5/2}$, is retarded by a factor of eight as compared to the corresponding one in $Pb^{207}$. (auth)

**33040** THE LIFETIMES OF THE FIRST EXCITED STATES OF $Re^{185}$ AND $Re^{187}$. A. E. Blaugrund, Y. Dar, G. Goldring, and E. Z. Skurnik (Weizmann Inst. of Science, Rehovoth, Israel). Nucl. Phys., 45: 54-9(July 1963) (In English)

Lifetimes of the first excited states of $Re^{185}$ and $Re^{187}$ were measured with the microwave method. From the slopes of the delayed curves a mean life of $1.45 \times 10^{-11}$ sec was found for the 134-kev level of $Re^{187}$ and an upper limit of $1.2 \times 10^{-11}$ sec could be determined for the 125-kev level in $Re^{185}$. (auth)

**33041** HALF-LIFE OF THE FIRST EXCITED STATE OF $I^{129}$. I. M. Govil, C. S. Khurana, and H. S. Hans (Muslim Univ., Aligarh, India). Nucl. Phys., 45: 60-4 (July 1963). (In English)

The half life of the first excited state of $I^{129}$ was measured from the slope of the delayed coincidence curve using time-to-pulse-height converter. The half life was found to be $T_{1/2} = (1.59 \pm 0.13) \times 10^{-8}$ sec. (auth)

**33042** ENERGY AND ANGULAR DISTRIBUTIONS OF PROMPT NEUTRONS FROM SLOW NEUTRON FISSION OF $U^{235}$. K. Skarsvag and K. Bergheim (Institutt for Atomenergi, Kjeller, Norway). Nucl. Phys., 45: 72-97 (July 1963). (In English)

The angular and energy distributions of prompt neutrons from slow neutron fission of $U^{235}$ were measured for energies 0.4–11.3 Mev and for angles 0–180° relative to the direction of motion of the light fragments. The analysis of the results gives as the main features that about 85% of the neutrons are evaporated isotropically from moving fragments with a Maxwellian energy distribution, and that about 15% of the neutrons are emitted during the fission process itself with an evaporation energy spectrum. (auth)

**33043** THE $^{12}C(p,p')^{12}C^{*}$ (12.71 AND 15.11 Mev) REACTION FROM THRESHOLD TO 50 Mev. D. F. Measday, P. S. Fisher, A. Kalmykov, F. A. Nikolaev, and A. B. Clegg (Nuclear Physics Lab., Oxford). Nucl. Phys., 45: 98-112(July 1963). (In English)

Excitation functions of the $C^{12}(p,p')$ reaction exciting two states of $C^{12}$ were measured by observing their decay gamma-radiation. The excitation of the 12.71-Mev state was measured for proton energies from threshold to 18.7 Mev, and the excitation of the 15.11-Mev state was measured for proton energies from threshold to 48.5 Mev. A strong peak is seen, at a proton energy of 20 Mev, in the excitation function for exciting the 15.11-Mev state; it is

suggested that this is due to a final state interaction between the outgoing proton and the $C^{12}$ excited state. (auth)

**33044** THE $^{12}C(p,\gamma)$ REACTION FROM 10 TO 50 Mev. P. S. Fisher, D. F. Measday, F. A. Nikolaev, A. Kalmykov, and A. B. Clegg (Nuclear Physics Lab., Oxford). Nucl. Phys., 45: 113-22(July 1963). (In English)

The excitation functions for radiative proton capture reactions leading to the $N^{13}$ ground state ($C^{12}(p,\gamma_0)N^{13}$) and to a state at 3.5 Mev in $N^{13}$($C^{12}(p,\gamma_2)N^{13*}$) were measured with incident proton energies from 10 to 48.5 Mev. The excitation function for the ground state reaction shows strong peaks at excitations in $N^{13}$ of 13, 20, and 32.5 Mev. If these are interpreted as the regions of strong E1 radiative strength the results are in good agreement with the $T = \frac{1}{2}$ dipole states predicted in the shell model calculations of Easlea. The excitation function for radiative capture to the excited state has a peak at an excitation of 24.5 Mev in $N^{13}$ and above that energy falls slowly with increasing energy, being still detectable at the maximum proton energy of 48.5 Mev. (auth)

**33045** INVESTIGATION OF THE REACTION $Al^{27}(p,\alpha_0)Mg^{24}$ IN THE PROTON ENERGY RANGE 1-2.5 MEV. M. A. Abuzeid, F. M. Aly, Y. P. Antoufiev, A. T. Baranik, T. M. Nower, and P. V. Sorokin (Atomic Energy Establishment, Cairo, Egypt). Nucl. Phys., 45: 123-8 (July 1963). (In English)

The excitation function of the reaction $Al^{27}(p,\alpha_0)Mg^{24}$ was measured in the proton energy range 1-2.5 Mev. Angular distributions are measured for most of the resonances. Resonance strengths were determined and the possible values of spins and parities of resonance levels of compound nucleus $Si^{28}$ are given. (auth)

**33046** STRUCTURE OF NUCLEAR ROTATION BANDS ACCORDING TO THE PEIERLS-YOCCOZ THEORY OF COLLECTIVE MOTION. B. J. Verhaar (Technische Hogeschool, Eindhoven, Netherlands). Nucl. Phys., 45: 129-41(July 1963). (In English)

It is shown that the Peierls-Yoccoz theory of nuclear collective motion gives a natural explanation for the decoupling effect in the case of $K = \frac{1}{2}$ rotation bands of odd-mass nuclei and for the odd-even shift in the case of K = 0 rotation bands of odd nuclei. Furthermore, the theory implies some additional modifications of the I(I + 1) energy law. An estimate of the effects is given. (auth)

**33047** K SHELL INTERNAL CONVERSION COEFFICIENTS AT THRESHOLD. R. F. O'Connell (Univ. of Notre Dame, Ind.). Nucl. Phys., 45: 142-55(July 1963). (In English)

Coulomb field effects on K shell internal conversion coefficients for threshold values of the gamma-ray energy are investigated using exact wave functions to describe both the bound and the continuum state electrons. Exact results for the internal conversion coefficients are obtained in terms of gamma functions and confluent hypergeometric functions. To facilitate numerical evaluation, the exact result is expanded in a series in $\alpha Z$ and the first three terms of this series are retained. The dominant terms are identical to the expressions obtained by Drell and by Dancoff and Morrison, in the non-relativistic approximation. Terms of order $\alpha Z$ times the dominant term are shown to be zero but the $\alpha^2Z^2$ corrections to the non-relativistic results are seen to bring the analytical results into closer agreement with the numerical results of Spinrad. The effects of finite nuclear size and screening are also considered. (auth)

**33048** OPTICAL MODEL FOR CROSS SECTIONS OF RADIATIVE CAPTURE AND INELASTIC NEUTRON SCATTERING. P. E. Nemirovskii and Yu. P. Yelagin (Kurchatov Atomic Energy Inst., Moscow). Nucl. Phys., 45: 156-63 (July 1963). (In English)

The application of the optical model to the calculation of inelastic scattering with excitation of low-lying levels and radiative capture cross sections is considered. A satisfactory agreement with experiment is obtained. (auth)

**33049** SINGLE PARTICLE STRENGTHS IN NUCLEI. G. E. Brown (Massachusetts Inst. of Tech., Cambridge), J. A. Evans, and D. J. Thouless. Nucl. Phys., 45: 164-76(July 1963). (In English)

Whereas one usually assumes that nearly all the single particle strength is in the neighborhood of the shell-model levels, it is pointed out that coupling of the particle with odd-parity vibrations shift an appreciable part of the strength several Mev away. Schematic calculations are carried out for nuclei neighboring to $O^{16}$ and $Ca^{40}$. It is shown that the approximation used is reliable if and only if the coupling between a particle level and the vibration is weak. (auth)

**33050** A DETERMINATION OF THE ABSOLUTE ENERGY OF THE $Hg^{198}$ 412 kev γ-RADIATION. G. Murray, R. L. Graham, and J. S. Geiger (Atomic Energy of Canada Ltd., Chalk River, Ont.). Nucl. Phys., 45: 177-96(July 1963). (In English)

The energy of the $Hg^{198}$ 412-kev γ ray has been compared with the energy of the narrow (no Doppler spread) component of the annihilation radiation emitted from completely thermalized positonium in ice. This comparison was made with the Chalk River $\pi\sqrt{2}\beta$-spectrometer using external conversion electron techniques. The momentum of the $Hg^{198}$ 412-kev $L_{III}$ external conversion electron line from a 0.67 mg/cm$^2$ uranium radiator was compared with the momentum of the annihilation radiation K external conversion electron line from the same radiator at a momentum resolution of ≈0.09%. The momentum ratio of these conversion lines was found to be 0.998761 ± 0.000010. The $Hg^{198}$ γ-ray energy has been deduced from this momentum ratio using both the 1955 and the 1961 (preliminary) sets of least-squares adjusted fundamental constants; the resulting $Hg^{198}$ γ-ray energy values are 411.770 ± 0.010 kev and 411.799 ± 0.007 kev, respectively. (auth)

**33051** COLLECTIVE EFFECTS AND ELASTIC SCATTERING FROM ODD-MASS NUCLEI. G. R. Satchler (Oak Ridge National Lab., Tenn.). Nucl. Phys., 45: 197-208(July 1963). (In English)

It is suggested that a difference could be observed between the elastic scattering from even and odd-mass nuclei whenever the nuclei are nonspherical. To second-order in the "deformation" the difference is shown to be mainly due to an additional diagonal matrix element which occurs for odd-mass nuclei with spin $> \frac{1}{2}$. Numerical evaluation of this matrix-element using the distorted-waves Born-approximation is used to give an estimate of the size and qualitative behavior of this effect in a number of typical cases. It is found that, while not large, the effect need not be negligible, and may be important for understanding the variations in optical potential parameters from nucleus to nucleus. Apart from this effect, arguments are given that the collective effects on the scattering from odd-mass nuclei are essentially the same as for neighboring even nuclei, (possibly with a change in the effective deformation), provided the scattering is approximately adiabatic. (auth)

**33052** STUDY OF THE GIANT RESONANCE IN $O^{16}$ BY INELASTIC ELECTRON SCATTERING. D. B. Isabelle and G. R. Bishop (Ecole Normale Superieuer-Laboratoire, Orsay, France). Nucl. Phys., 45: 209-34(July 1963). (In English)

The spectra of electrons inelastically scattered by oxygen nuclei show a series of prominent peaks which are assumed to correspond to the excitation of discrete levels. By varying the incident electron energy and the scattering angle, the dependence of the inelastic form factor on momentum transfer is studied. Use of the Born approximation for the scattering cross section then enables one to determine the multipolarity and parity change of the transitions. Results and analysis are presented of E1 transitions to excited states at 22.6 and 25.7 Mev, and of an E2 transition to an excited state at 24.1 Mev. The E1 transitions are probably those responsible for the giant resonance observed in the photoproduction of neutrons and protons from oxygen. Details are given of calculations of radiative tails and of radiative corrections to the data. (auth)

**33053** THE POLARIZATION OF NEUTRONS FROM THE $Be^9(p,n)B^9$ REACTION. C. A. Kelsey (Univ. of Wisconsin, Madison). Nucl. Phys., 45: 235-42(July 1963). (TID-18419). (In English)

The polarization of neutrons from the $Be^9(p,n)B^9$ reaction has been measured for several energies and angles in the region between 3.7 and 8.5 Mev bombarding energy. Energy discrimination was used to reduce the contribution of the breakup neutrons, and time-of-flight spectra have been obtained to determine the amount of breakup contamination present. The results indicate that for an emission angle of 30° the polarization has a value of 0.2 at 3.7 Mev, changes sign near 4.3 Mev, and reaches a value of $-0.4$ near 5 Mev. At emission angles of 50 and 70°, polarizations of the order of $-0.3$ were observed in the energy region between 6.0 and 8.5 Mev. (auth)

**33054** THE OBSERVATION OF $Be^8$ IN THE GROUND STATE. J. A. Weinman and R. K. Smither (Argonne National Lab., Ill.). Nucl. Phys., 45: 260-72(July 1963). (In English)

This investigation demonstrates the feasibility of detecting $Be^8$ in the ground state as a reaction product in the presence of competing reaction products. The requisite techniques are described. The $Be^9 + He^3$ reaction at $E(He^3) \leq 2.0$ Mev was employed in this study. Angular distributions of $Be^9(He^3,\alpha)Be^8$ and $Be^9(He^3,p)B^{11}$ at $E(He^3) = 2.0$ Mev are also presented. (auth)

**33055** THE $^{23}Na(d,p)^{24}Na$ REACTION AND THE NUCLEAR STRUCTURE OF $^{24}Na$. C. Daum (Univ. of Michigan, Ann Arbor). Nucl. Phys., 45: 273-95(July 1963). (In English)

The level scheme of $Na^{24}$ up to about 7 Mev has been studied with the $Na^{23}(d,p)Na^{24}$ reaction. Several new levels have been observed. A few discrepancies in energy assignment to levels exist between these and earlier experiments. The angular distributions have been analyzed with the DWBA analysis. A BBA analysis checks well with earlier results. Spectroscopic data have been obtained for many of the levels. (auth)

**33056** A STUDY OF THE DECAY OF $V^{48}$. R. A. Ristinen, A. A. Bartlett, and J. J. Kraushaar (Univ. of Colorado, Boulder). Nucl. Phys., 45: 321-35(July 1963). (UCOL-P-515). (In English)

The low excited states of $Ti^{48}$ have been studied by examining the gamma- and beta-ray spectra following the decay of $V^{48}$. The study utilized a double-focusing, $\sqrt{2}\pi$ beta-ray spectrometer and gamma-ray scintillation spectrometers with associated coincidence circuitry and pulse-height analysis systems. The energies and relative intensities of the observed nuclear transitions are 944.9 ± 0.7 kev (9.8 ± 0.9), 983.3 ± 0.4 kev (100), 1311.7 ± 0.6 kev (98.0 ± 3.2), 2240.6 ± 1.0 kev (2.9 ± 0.2), and 2.64 ± 0.02 Mev (0.04 ± 0.02). By coincidence techniques, the 945, 1312, and 983 kev gamma rays were established as the members of a triple cascade of nuclear transitions which originates at a newly found excited level at 3240 kev and ends at the ground state. The 2241 and 983 kev gamma rays were observed to form a double cascade to the ground state. The 2.64 Mev gamma ray has been assigned as the transition from a previously reported level at 3.62 Mev to the first excited state. As the result of an experimental determination of the internal conversion coefficient for the 945 kev transition, the multipolarity has been found to be predominantly M1, and a spin and parity assignment of $(5^+)$ has been proposed for the new energy level at 3240 kev. A level scheme which incorporates the findings of this study has been constructed for $Ti^{48}$. (auth)

**33057** LOW-LYING STATES IN $Al^{26}$. P. Horvat, P. Kump, and B. Povh (Nuclear Inst. "Josef Stefan," Ljubljana, Yugoslavia). Nucl. Phys., 45: 341-51(July 1963). (In English)

The gamma cascades from 7.220, 7.252, and 7.539 Mev levels in $Al^{26}$ have been studied by means of the $(p,\gamma)$ reaction on $Mg^{25}$. The $(p,\gamma)$ and $(p,\gamma\gamma)$ angular correlations give spin and parity assignments to the 2.07, 1.85, and 1.76 Mev levels in $Al^{26}$. The configurations of the levels below 2.5 Mev excitation are discussed. (auth)

**33058** FISSION CROSS SECTION OF $U^{235}$. C. D. Bowman, G. F. Auchampaugh, and S. C. Fultz (Univ. of California, Livermore). Phys. Rev., 130: 1482-91(May 15, 1963). (UCRL-6926(Rev.))

The fission cross section of $U^{235}$ was investigated with high resolution between 0.03 and 60 ev using the neutron time-of-flight facility at the Livermore linear electron accelerator. Normalization of the relative cross sections in the thermal region indicates that the fission cross sections generally accepted are about 20% too large in the region between 5 and 60 ev. Values for $\sigma_0\Gamma_f$ and $\Gamma_f$ above 5 ev are compiled and are compared with similar measurements by other investigators. Evidence is also presented which indicates that the fission widths fall into two groups probably related to the two total angular momenta involved in the reaction. (auth)

**33059** GAMMA RAY TRANSITIONS IN $^{35}Cl$. N. Hazewindus, W. Lourens, A. Scheepmaker, and A. H. Wapstra (Technische Hogeschool, Delft, Netherlands). Physica, 29: 681-705(June 1963). (In English)

The gamma-ray transitions in $Cl^{35}$ following proton capture in $S^{34}$ have been studied with scintillation spectrometers. The investigation was restricted to 9 resonances between proton energies 0.756 and 1.214 Mev. The resonance strengths were measured. The resulting excited states in $Cl^{35}$ at about 7.2 Mev decay to known levels at 1.22, 1.76, 2.64, 2.69, 3.16, 4.06, and 4.17 Mev and to new ones at 5.03 ± 0.05 and 5.22 ± 0.04 Mev. Branching ratios were measured for all levels. (auth)

**33060** RADIATIVE CAPTURE OF HEAVY IONS. J. H. Fremlin and P. Reasbeck (Univ. of Birmingham, Eng.). Proc. Phys. Soc. (London), 82: 110-12(July 1963).

A search was made for $P^{32}$ produced by the reaction $F^{19}(C^{13},\gamma)P^{32}$. Lithium fluoride was bombarded by ions of $C^{13}$. $P^{32}$ was observed and its identity confirmed by meas-

urement of its half life and by chemical separation. The yield was about one part in $10^4$ of the total yield of radioactive nuclides. (auth)

**33061** ELECTRON CAPTURE BY FAST PROTONS IN HYDROGEN. I. M. Cheshire (The University, Glasgow). Proc. Phys. Soc. (London), 82: 113-16(July 1963).

The impulse approximation is used to calculate the cross section for the resonant capture process $H^+ + H(1s) \rightarrow H(1s) + H^+$ at various incident proton energies up to 1125 kev. The results are compared with previous calculations. By estimating the probability of capture into excited states the total cross section is calculated and compared with experimental results for protons in molecular hydrogen. (auth)

**33062** ISOTOPE SHIFTS IN THE RESONANCE LINE OF THE ARC SPECTRUM OF BARIUM. D. A. Jackson and Duong-hong Tuan (CNRS, Bellevue, France). Proc. Roy. Soc. (London), Ser. A, 274: 145-53(July 23, 1963).

Measurements of the isotope shifts in the resonance line of Ba I of all of the stable isotopes of barium were made by comparing the wavelengths of the lines, unresolved blends, emitted by enriched isotopes. The shifts relative to $Ba^{138}$ are: 7.7 mK; $Ba^{136}$, 4.2 mK; $Ba^{135}$, 8.4 mK; $Ba^{134}$, 4.6 mK; $Ba^{132}$, 7.4 mK; $Ba^{130}$, 7.8 mK. The shifts for $Ba^{136}$ and $Ba^{134}$ are in agreement to within 0.1 mK with those found by Razumovski & Chaika, but their values for $Ba^{137}$ and $Ba^{135}$ are respectively 2.0 and 0.8 mK lower, possibly due to insufficient blending of the weakest hyperfine structure component. The hfs intervals of the terms $6s6p\,^1P_1$ of the odd isotopes of $Ba^{137}$ and $Ba^{135}$ were derived from the results of measurements of the structure of the line emitted by natural barium combined with values of the isotope shifts and the already known ratios of the magnetic moment splitting factors, A, and the quadrupole moment coupling factors, B; approximate values are given of the factors A and B. (auth)

**33063** PROTON SCATTERING BY $F^{19}$ AND $Ar^{40}$ IN THE ENERGY INTERVAL 5.20 TO 6.23 Mev. H. Hulubei, M. Ivaşcu, A. Berinde, I. Neamu, I. Franz, and N. Martalogu. Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 107-19(1963). (In French)

Angular and energy distributions of protons scattered elastically and inelastically by $F^{19}$ and $Ar^{40}$ are measured. The data suggest that the excitation of $F^{19}$ in this interaction takes place principally by a direct process, while the excitation of $Ar^{40}$ is brought about by a compound-nucleus process. (T.F.H.)

**33064** INFLUENCE OF RESIDUAL INTERACTIONS ON NUCLEON–NUCLEUS INELASTIC COLLISION. Ileana Guiaşu and M. Micu (Inst. of Atomic Physics, Bucharest). Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 205-16 (1963). (In English)

A nuclear model is described in which the nucleons interact through harmonic-oscillator potentials in the j-j coupling shell model, with superconducting-like and collective residual interactions between pairs of nucleons. The nuclear wave functions and interaction Hamiltonians for nucleon-nucleus reactions are derived. Single-particle transitions and excitation of collective levels are discussed. (T.F.H.)

**33065** THE CALCULATION OF THE BRANCHING PERIOD OF THE $Be^8$ ISOTOPE. Ion Stan. Studia Univ. Babes-Bolyai, Ser. 1, No. 1, 155-9(1959). (In Rumanian)

The branching period of the $Be^8$ isotope was calculated using the interaction energy between two charged spheres of equal radii. The value $T_{\frac{1}{2}} = 2.2 \times 10^{-15}$ was found for the ground level. (tr-auth)

**33066** REDUCED NUCLEAR LEVEL WIDTHS FROM NUCLEAR REACTIONS. M. I. Zaika. Ukr. Fiz. Zh., 8: 492-4(Apr. 1963). (In Ukrainian)

On investigating nuclear reactions such as a (d,p) reaction, it is possible to obtain information on the nature of the nuclear levels, if the values of the reduced neutron widths of these levels are known. Values of the reduced widths of low-lying, rotational nuclear levels can be obtained in this way in a number of cases. These data are valuable in predictions of nuclear models. The angular distribution of protons from a (d,p) reaction with 13.6-Mev deuterons was determined by means of an ionization spectrometer. The absolute cross sections in millibarns per steradian were tabulated for (d,p) reactions on $Be^9$, $C^{12}$, $Si^{28}$, $Si^{29}$, $Ca^{40}$, $Ti^{46}$, $Ti^{48}$, $Sr^{88}$, $Zr^{90}$, $Zr^{91}$, and $Cd^{113}$. Experimental values of the reduced neutron widths $\Theta_0^2$ were taken from the article by MacFarland and French (Revs. Mod. Phys., 23: 567 (1960)), and an experimental ratio $S_{exp.} = \Theta^2/\Theta_0^2$ was calculated. The experimental value $S_{exp.}$ was in good agreement with the theoretical ratio $S_{theor.}$. $Be^9$ and $C^{14}$ formed an intermediate compound nucleus, while a collective model must be used with $Si^{29}$. A comparison of $S_{exp.}$ with $S_{theor.}$ shows that most of the levels are single-particle levels. (TTT)

**33067** ROLE OF THE COULOMB INTERACTION IN THE (d,p)-REACTION. A. M. Korolev (Inst. of Physics, Kiev). Ukr. Fiz. Zh., 8: 523-31(1963). (In Ukrainian)

The (d,p)-reaction is considered in the Born approximation of the perturbation theory. The energy of the incident deuterons is assumed to be so high that the initial deuteron and the final proton waves are not distorted by the nuclear and Coulomb interaction potentials, and these interactions are considered as perturbations. An expression is obtained for the angular distributions of protons of the (d,p)-reaction, taking into account the Coulomb interaction. Allowing for this interaction leads to the widening of the Butler peaks in the angular distribution and to their displacement toward the large angles. In addition, owing to the increase in contribution with large angles, there should be a less distinct picture of angular distribution as compared to Butler distribution. A calculation of some Coulomb integrals is appended. (auth)

**33068** SPLITTING OF DEUTERONS DURING SCATTERING BY NUCLEI. E. Ismatov and I. E. Kashuba (Inst. of Physics, Kiev). Ukr. Fiz. Zh., 8: 532-6(1963). (In Ukrainian)

The splitting of deuterons by nuclei at energies above the Coulomb barrier is considered. The interaction of the neutron and the proton with the nucleus is taken into consideration. As in most researches in direct interactions, perturbation theory was applied in this study. The single-particle potentials were approximated by means of Gaussian functions with depths, $\overline{V}_n$ and $\overline{V}_p$ respectively. In addition, it is assumed that the ratio of the deuteron radius to the nucleus radius is small. The splitting process under consideration leads to a decrease in the elastic scattering cross section. The computed differential and total cross sections of the process agree qualitatively with the experimental data for $Al^{27}$. (auth)

**33069** IMPORTANCE OF LIFE TIME CORRELATION EXPERIMENTS. Hwan-wu Peng. Wu Li Hsueh Pao, 18: 165-6(Mar. 1962). (In Chinese)

A two-step decay process $A \rightarrow B \rightarrow C$ is considered, with lifetimes $t_1$ and $t_2$ for the two steps respectively. It is proposed that an experiment be conducted to measure the average values of $t_1$ and $t_2$, and the correlation between the two lifetimes. Quantum theory predicts that no correlation

exists; thus if a correlation were observed experimentally, doubt would be cast on the validity of quantum mechanics. (T.F.H.)

**33070** THE (p,α) REACTION AT 20 Mev. A. P. Klyucharev, G. E. Krivets, and N. Ya. Rutkevich (Inst. of Physics and Tech., Acad. of Sciences, Ukrainian SSR). Zh. Eksperim. i Teor. Fiz., 44: 1753-9(June 1963). (In Russian)

The (p,α) reaction was studied on cobalt and platinum of natural composition and on nickel, copper, zinc, and tin isotopes for 20.5-Mev protons. For most of the targets the differential cross section of the reaction decreased with increase of the mass number. The energy and angular distribution of the α particles showed the presence of two reaction mechanisms, a direct reaction and a reaction proceeding via compound-nucleus formation. (auth)

**33071** ELASTIC SCATTERING OF DEUTERONS ON CHROMIUM AND ZINC ISOTOPES. A. K. Valter, A. P. Klyucharev, O. F. Nemets, and V. V. Tokarevskii (Inst. of Physics, Academy of Sciences, Ukrainian SSR). Zh. Eksperim. i Teor. Fiz., 44: 1765-9(June 1963). (In Russian)

The angular distributions of 13.6-Mev deuterons elastically scattered on $Cr^{50,52,53,54}$ and $Zn^{64,66,70}$ isotopes are measured at angles from 2.5 to 150°. The ratio of the experimentally measured cross section to the coulomb scattering cross section has a diffraction nature. With growth of the number of neutrons the maxima shift towards smaller angles and the cross section begins to decrease at a higher rate with increase of the angle. (auth)

**33072** RATIO OF THE CROSS SECTIONS FOR FORMATION OF THE ISOMER AND GROUND STATES OF NUCLEI IN THE (p,n)-REACTION AT ENERGIES FROM THE THRESHOLD TO 20 Mev. V. T. Gritsyna, A. P. Klyucharev, V. V. Remaev, and L. N. Reshetova (Inst. of Physics and Tech., Khar'kov). Zh. Eksperim. i Teor. Fiz., 44: 1770-4(June 1963). (In Russian)

Cross sections for the reactions $Y^{89}(p,n)Zr^{89m}$, $Y^{89}(p,n)Zr^{89g}$, $Pr^{141}(p,n)Nd^{141m}$, $Pr^{141}(p,n)Nd^{141g}$, $Au^{197}(p,n)Hg^{197m}$, and $Au^{197}(p,n)Hg^{197g}$ are measured with the purpose of studying the mechanism of nuclear reactions for incident particle energies ranging from the threshold of the (p,n) reaction up to 20 Mev. The ratios of the cross sections for production of isomer and ground states in (p,n) reactions are discussed under the assumption that the compound nucleus mechanism is involved. (auth)

**33073** DETERMINATION OF THE SIZE OF NUCLEI FROM THE DIFFERENTIAL $\pi^0$-MESON PHOTOPRODUCTION CROSS SECTIONS. B. B. Govorkov, S. P. Denisov, and E. V. Minarik (Lebedev Inst. of Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1780-6 (June 1963). (In Russian)

Angular distributions of $\pi^0$ mesons produced by γ quanta with a mean energy of 182 Mev are presented. These data, and those obtained by studying photoproduction at 154 Mev, are analyzed with the purpose of obtaining information concerning the distribution of nucleons in Be, C, Al, Cu, Cd, Ta, and Pb nuclei. (auth)

**33074** ANGULAR AND ENERGY DISTRIBUTIONS OF PHOTONEUTRONS FROM BISMUTH, GOLD AND TANTALUM. G. N. Zatsepina, V. V. Igonin, L. E. Lazareva, and A. I. Lepestkin (Lebedev Inst. of Physics, Academy of Sciences, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1787-99(June 1963). (In Russian)

Results of measurements of the angular and energy distributions of photoneutrons from bismuth, gold, and tantalum irradiated by 14- and 19-Mev peak-energy x rays are presented. The results are analyzed from the standpoint of the independent-particle model. (auth)

**33075** SEARCH FOR SECONDARY DEUTERIUM AND TRITIUM CAPTURE REACTIONS. Chuan-pen Wang, V. N. Mekhedov, V. N. Rybakov, and R. A. Shimchak (Joint Inst. of Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1800-5(June 1963). (In Russian)

The yields of heavy arsenic isotopes produced by bombarding germanium with 120-, 300-, 480-, and 660-Mev protons are measured by a radiochemical method. With increase of the proton energy all yields monotonically decrease, and for $As^{74}$ nucleus the value is 3.4 to 1.0 mb, for $As^{76}$ 1.0 to 0.38 mb, and for $As^{77}$ and $As^{78}$ 0.13 to 0.035 mb. The primary (p,xn) reactions apparently underlie the formation of $As^{74}$ and $As^{76}$. The $As^{78}$ isotope is probably produced as a result of capture of superbarrier tritium nuclei. The origin of the $As^{77}$ isotope is more intricate. At low proton energies (120 and 300 Mev) it is mainly produced as a result of secondary capture of deuterium and tritium. At higher proton energies most of this isotope is evidently produced as a result of secondary reactions of α capture. (auth)

**33076** RESONANCE SCATTERING OF γ-QUANTA ON $Cu^{65}$ AND $Ti^{46}$ NUCLEI. D. K. Kaipov, R. B. Begzhanov, A. V. Kuziminov, and Yu. K. Shubnyi (Inst. of Nuclear Physics, Academy of Sciences, Kazakh SSR). Zh. Eksperim. i Teor. Fiz., 44: 1811-17(June 1963). (In Russian)

The lifetimes of the excited states of $Cu^{65}$ and $Ti^{46}$ nuclei with energies 1.114 and 0.890 Mev are measured by the method of nuclear resonance scattering, employing $Ni^{65}$ and $Sc^{46}$ sources in $NiCl_2$ and $ScCl_3$. For the 0.890-Mev level of $Ti^{46}$ the lifetime $(1.42 \pm 0.20) \cdot 10^{-11}$ sec is obtained. The lifetime of the 1.114 Mev level of $Cu^{65}$ is found to be $(6.5 \pm 1.6) \cdot 10^{-13}$ sec, which corresponds to $\tau_\gamma = 8 \cdot 3 \cdot 10^{-13}$ sec for $\tau_\gamma$ relative to the M1-transition and a E2- to M1-transition intensity ratio $\delta^2 = 0.32$. (auth)

**33077** TWO-ELECTRON CHARGE OF LOW-ENERGY PROTONS. V. F. Kozlov, Ya. M. Fogel, and V. A. Stratienko (Inst. of Physics and Tech., Academy of Sciences, Ukrainian SSR). Zh. Eksperim. i Teor. Fiz., 44: 1823-5 (June 1963). (In Russian)

The effective cross sections $\sigma_{1-1}$ for two-electron charge exchange of 0.5- to 5-kev protons in hydrogen, argon, and krypton are measured. (auth)

**33078** GROUND STATE OF THE $Be^6$ NUCLEUS. M. Gulyamov, B. V. Rybakov, and V. A. Sidorov. Zh. Eksperim. i Teor. Fiz., 44: 1829-31(June 1963). (In Russian)

The spectrum of neutrons from the $Li^6(p,n)Be^6$ reaction is investigated by the time-of-flight method for 9.96-Mev protons. A value of the reaction energy is obtained ($Q = -5.08 \pm 0.04$ Mev), and the width of the ground state of $Be^6$ is derived ($\Gamma = 0.14 \pm 0.04$ Mev). (auth)

**33079** TRIPLE FISSION OF PLUTONIUM. N. A. Perfilov, Z. I. Soloveva, R. A. Filov, and G. I. Khlebnikov. Zh. Eksperim. i Teor. Fiz., 44: 1832-6(June 1963). (In Russian)

The energy spectra of long-range α particles produced in spontaneous fission of $Pu^{238}$ and $Pu^{240}$, and in the fission of $Pu^{239}$ by thermal neutrons, are studied by the nuclear emulsion method. The shapes of the spectra are discussed and are compared with the results of complex fission of uranium. (auth)

**33080** FORMATION OF MESIC HELIUM ATOMS IN A GAS MIXTURE CONTAINING HELIUM AND HYDROGEN. O. A. Zaimidoroga, M. M. Kulyukin, R. M. Sulyaev, A. I. Filippov, V. M. Tsupko-Sitnikov, and Yu. A. Shcherbakov

(Joint Inst. of Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1852-8(June 1963). (In Russian)

The formation of helium mesic atoms in a mixture of helium and hydrogen is studied in a diffusion cloud chamber at 19 atmospheres. It is shown that the probability of capture of $\mu$ mesons by helium from a hydrogen mesic atom in the ground state is at least three orders of magnitude smaller than the probability of capture by carbon or oxygen nuclei and cannot exceed appreciably $10^6$ $sec^{-1}$, a result which is in agreement with the theoretical estimates. There are indications that for direct attachment of the mesons to the nuclei of the gas mixture agreement with the "Z-law" should hold. (auth)

**33081** EMISSION OF $Li^8$ FRAGMENTS IN THE DISINTEGRATION OF Ag AND Br NUCLEI BY 19 Bev PROTONS. N. P. Bogachev, A. G. Volodko, E. L. Grigorev, and Yu. P. Merekov (Joint Inst. of Nuclear Research, Dubna, USSR). Zh. Eksperim. i Teor. Fiz., 44: 1869-72(June 1963). (In Russian)

The formation of $Li^8$ on Ag and Br nuclei in photographic emulsions induced by 19-Bev protons was investigated. Such fundamental characteristics of the process of emission of $Li^8$ in disintegrations with a number of black prongs $N_b \geq 8$ as the yield per disintegration, energy and angular distributions, and some data on the ejection of two fragments in a single disintegration are presented. A comparison of the data of the process for various primary proton energies shows that in a broad energy range the main characteristics of the process remain the same. (auth)

**33082** DETERMINATION OF THE FISSION THRESHOLD FROM EXPERIMENTS ON THE (d,pf) AND ($\gamma$,f)-REACTIONS. L. N. Usachev, V. A. Pavlinchuk, and N. S. Rabotnov. Zh. Eksperim. i Teor. Fiz., 44: 1950-2(June 1963). (In Russian)

The experimental data on the energy dependence of the cross sections of (d,pf) reactions on $U^{233}$, $U^{235}$, and $Pu^{239}$ nuclei at excitation energies smaller than the binding energy of the neutron in the compound nucleus are interpreted under the assumption that for a completely open fission channel the fission width is much greater than the radiative, this assumption being consistent with estimates made on the basis of the Bohr-Wheeler formula. It is demonstrated that the alternative assumption ($\Gamma_f \ll \Gamma_\gamma$) yields fission threshold values that are lower than the true one by several hundred kev. (auth)

**33083** CROSS SECTION BEHAVIOR NEAR THE THRESHOLD OF A NEW REACTION IN THE CASE OF A COULOMB ATTRACTION FIELD. M. Gailitis (Inst. of Physics, Academy of Sciences, Latvian SSR). Zh. Eksperim. i Teor. Fiz., 44: 1974-81(June 1963). (In Russian)

The multi-channel effective radius theory is extended to the case of a Coulomb attraction field. It is shown that the presence of resonances in the cross sections below the threshold of the new reaction results from this theory. Expressions are derived for the mean cross sections, widths, and resonance shifts. (auth)

**33084** KINETICS OF INDUCED MÖSSBAUER RADIATION. B. V. Chirikov (Inst. of Nuclear Physics, Academy of Sciences, Siberian SSR). Zh. Eksperim. i Teor. Fiz., 44: 2016-22(June 1963). (In Russian)

The kinetics of forced Mössbauer radiation in an infinite crystal, under conditions when the characteristic time of the process is much less than the line width, is considered. It is shown that the wave peak should move with a very small velocity, proportional to the line width. (auth)

**33085** DIRECT NUCLEAR REACTIONS AND INTERACTION IN THE INITIAL AND FINAL STATES. V. A. Kaminskii and Yu. V. Orlov (Moscow State Univ.). Zh. Eksperim. i Teor. Fiz., 44: 2090-9(June 1963). (In Russian)

A formal scheme for taking into account interactions in the initial and final states in direct nuclear reactions is developed. Unitarity of the S-matrix and the analytic properties of the reaction amplitude as a function of energy are employed. A solution of the singular integral equation for the partial amplitude of the reaction is derived. It is shown that the existence of a significant singularity of the $e^{-ikR}$ type related to the size of the nucleus does not modify the result. The solution can be factorized into two terms, one of which contains all singularities connected with interaction in the initial and final states; the singularities of the second factor are determined by the mechanism of the reaction. One of the functions is calculated for a rectangular well. The problem of bound states of the system is considered. The solution for the partial amplitude of the reaction satisfies the physical requirements defining a unique solution and possesses the correct behavior near the threshold. The solution also takes into account resonance effects of the compound nucleus in direct nuclear reactions. A boundary problem method is proposed, which is equivalent to the dispersion method but is more graphic. (auth)

**33086** ANGULAR DISTRIBUTIONS FOR $N^{14}(d,d)N^{14}$ FROM 0.7–2.1 Mev. 12p. (CONF-46-19)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

Absolute cross sections for the $N^{14}(d,d)N^{14}$ reaction were measured with a gas target in a differentially pumped scattering chamber. Excitation functions were measured at the center-of-mass angles of 90, 125.3, 140.8, and 166.5° over the energy range from 0.650–2.0 Mev. There is no pronounced resonant structure in the data although the cross sections are depressed below the calculated Rutherford cross sections over the entire energy range. Angular distributions were measured every 200 kev from 0.7–2.1 Mev for the center-of-mass angular range from 20 to 165°. (C.E.S.)

**33087** ON THE THEORY OF MULTIPLE COULOMB EXCITATION WITH HEAVY IONS. Kurt Alder (Univ. of Basel). 20p. (CONF-62-4)

From Conference on Reactions Between Complex Nuclei, Asilomar, Calif., Apr. 1963.

A collective nuclear model for the low-lying spectrum is used to discuss multiple Coulomb excitation with heavy ions. Pure rotational and vibrational bands, coupled rotational bands, and rotational bands of non-axial nuclei are used as specific nuclear models. Excitation probabilities, differential and total cross sections, and the angular distribution of the de-excitation gamma rays are computed from the derived excitation amplitudes. The differential and total cross sections and normalized angular distribution coefficients for inelastic scattering with excitation of the states with even rotational spin are presented. (C.E.S.)

**33088** ANGULAR DISTRIBUTIONS OF $\alpha$-PARTICLES FROM $Li^6$-INDUCED REACTIONS. Shigeru Takeda and Ryuzo Nakasima (Tokyo Inst. of Tech.). 6p. (CONF-62-3)

From Conference on Reactions Between Complex Nuclei, Asilomar, Calif., Apr. 1963.

The angular distributions of alpha particles from $Li^6(Li^6,\alpha)Be^8$ and $C^{12}(Li^6,\alpha)N^{14}$ reactions are discussed. The angular distribution of the alpha particle group leav-

ing $Be^8$ in the ground state is analyzed by plane wave Born approximation in stripping reactions. The difference between the alpha groups associated with the ground and second-excited states of $N^{14}$ is also discussed. Expressions for the differential cross section and the reduced width amplitudes are also derived. (C.E.S.)

**33089** ENERGIES AND YIELDS OF PROMPT NEUTRONS FROM INDIVIDUAL FRAGMENTS IN THE FISSION OF $U^{233}$ + n. J. C. D. Milton. 11p. (CONF-46-26)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

Neutrons from a reactor strike a fissionable source ($U^{233}$ in this case), and a time-of-flight system is used to study the behavior of fragments. The number of neutrons, the average neutron energy, and information on the error in the latter are derived. Results for $U^{233}$ support a model for the process in which the fragments are cold at separation, with one of the fragments highly distorted. A statistical model that treats the fragments as spherical and hot is shown not to be valid. (D.C.W.)

**33090** IDENTIFICATION OF SPIN $^3/_2$ AND $^1/_2$ LEVELS IN $Cr^{51}$, $Cr^{53}$, $Fe^{57}$, AND $Ni^{59}$. G. A. Bartholomew and M. R. Gunye. 12p. (CONF-46-55)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

An attempt was made to establish the spin ($^3/_2^-$ or $^1/_2^-$) of excited states displaying the characteristic $l_n = 1$ (d,p) stripping pattern. Gamma rays from the cascades beginning with a transition from the $^1/_2^+$ capturing state to the level in question that then decays to the ground state or some low-lying state were studied by coincidence counting at 90 and 180°. The asymmetry, W(180)/W(90), was determined permitting computation of the correlation coefficients. Spin assignments were derived from the correlations. (D.C.W.)

**33091** PRODUCTION OF DEUTERON, TRITON AND HELIUM BY 28 Bev AND 6.3 Bev PROTON INTERACTIONS IN NUCLEAR EMULSIONS. P. L. Jain. 4p. (CONF-46-51)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

The mechanism of d, t, and $He^3$ production in N-N and N-nucleus reactions was studied by exposing emulsions to 6.3 and 28-Bev protons. Stars with $N_h > 1$ were examined at both energies. At 6.3 Bev d and t production accounted for 2.5 and 1.3% of the tracks; at 28 Bev, 5 and 2%. The average d energy was 1.6 Bev at 6.3 Bev and 2.5 Bev at 28 Bev. Stars with $N_h \leq 1$ were also considered at 28 Bev. The d and t production percentages were 10 and 6%, respectively. N-N and N-nucleus reactions made equal contributions to d and t production with $N_h \leq 1$, and the production angles were less than 20°. The results show that neither the Butler theory nor the Hagedorn theory (reviewed) is correct in itself. (D.C.W.)

**33092** NEGATIVE PARITY STATES IN THE NUCLEAR (d,s) SHELL. M. Harvey (Atomic Energy of Canada Ltd., Chalk River, Ont.). 8p. (CONF-22-14)

From American Physical Society Meeting, New York, Jan. 1963.

A shell model study was made of the negative parity states in the nuclear (2s,1d) shell. The $SU_3$ model predicted such states for a K = 1 band cut off at $J = 3^-$ in $O^{16}$. The ordering of the levels ($J = 3^-$, $1^-$, and $2^-$) and the energies of the $J = 3^-$ and $1^-$ states agree with experiment. A K = 1 band in $O^{18}$, cut off at $J = 7^-$, is predicted. The level ordering is $J = 1^-$, $2^-$, $3^-$, etc. For $F^{19}$ and $O^{17}$, K = $^1/_2^-$ and $^3/_2^-$ bands are predicted. The K = $^1/_2^-$ band of $F^{19}$ is in good agreement with the lowest observed J = $^1/_2^-$, $^5/_2^-$, and $^3/_2^-$ levels. The J = $^1/_2^-$ level in $O^{17}$ has the lowest energy, but this energy is not consistent with the observed energy of the lowest negative parity state. (D.C.W.)

**33093** STUDY OF THE FISSION FRAGMENT KINETIC ENERGY AS A FUNCTION OF THE PROMPT GAMMA RAYS. Edward Lee Cooperman and R. R. Roy. 14p. (CONF-46-73)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Coincidence circuitry and ionization chambers were used to determine the angles of fragment emission and the angular and kinetic energy distribution of the fragments with respect to the direction of gamma emission. The procedures and equipment are described, and the results are graphically displayed. Structural effects were noted in the kinetic energy distribution. (D.C.W.)

**33094** RECOIL RANGE STUDIES OF NUCLEAR REACTIONS INDUCED BY HEAVY IONS. Morton Kaplan and Richard D. Fink (Yale Univ., New Haven). 21p. (CONF-62-5)

From Conference on Reactions Between Complex Nuclei, Asilomar, Calif., Apr. 1963.

The recoil properties of heavy residual products in heavy-ion induced reactions are investigated. The momenta received from the incident ion and that due to particle emission are equal to the vector sum of the linear momentum of the residual products in the beam direction. The specific reaction product $Sm^{142}$ was studied in reactions $Pr^{141}(Li^6,5n)$, $Cs^{133}(N^{14},5n)$, $Pr^{141}(Li^7,6n)$, $Ba^{136}(C^{12},6n)$, $La^{139}(B^{10},7n)$, and $Ba^{138}(C^{12},8n)$. (C.E.S.)

**33095** INDUCED EFFECTS IN BETA DECAY. J. N. Huffaker and Eugene Greuling (Duke Univ., Durham, N. C.). 7p. (CONF-46-14)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Effects induced in beta decay by the strong couplings of nucleons are discussed. Attention is given to the conservation of vector current, G invariance, and induced pseudoscalar coupling properties. A test of G invariance is proposed, which involves measurement of the $N^{16}$ beta spectrum at about 8 to 22 Mev total electron energy. (T.F.H.)

**33096** THE MÖSSBAUER EFFECT FOR AN IMPURITY NUCLEUS. I. THEORETICAL RESULTS FOR BRAVAIS CRYSTALS. A. A. Maradudin, P. A. Flinn, and J. M. Radcliffe (Westinghouse Research Labs., Pittsburgh). 68p. (CONF-22-3)

From American Physical Society Meeting, New York, Jan. 1963.

Formal expressions are derived for the no-phonon and one-phonon cross sections for the absorption of a gamma ray photon by an impurity nucleus in an arbitrary Bravais crystal. An expression is also derived for the second order Doppler shift in the energy of the gamma ray. Most of the analysis is carried out on the assumption that the impurity nucleus is a mass defect, but a brief discussion is also given for the case that the force constants associated with the impurity differ from those for a perfect host crystal. (auth)

**33097** $\alpha$-PARTICLE BREAKUP INDUCED BY INELASTIC SCATTERING OF $\alpha$ PARTICLES FROM $C^{12}$ AND $F^{19}$. R. A. LaSalle, R. D. Bent, and J. G. Cramer, Jr. (Indiana Univ., Bloomington). 13p. (CONF-46-31)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

Self-supporting targets of carbon and fluorine were bombarded with 22.5-Mev $\alpha$ particles. Two Ortec surface-barrier detectors mounted concentrically in the reaction plane were used in conjunction with a 1024-channel 2-parameter analyzer gated to display fast-coincidence events between inelastically scattered $\alpha$ particles and resulting breakup $\alpha$ particles from unbound levels in $C^{12}$ and $F^{19}$. Energy and angle correlations were measured over a range of scattering angles from 20–160° (lab.). Breakup of the 9.63-Mev state of $C^{12}$ indicates that the decay proceeds primarily through a 2-step process; $C^{12}_{9.63} \rightarrow Be^8 + \alpha$; $Be^8 \rightarrow 2\alpha$. The sharp angular correlations observed are consistent with a J = 3 assignment for the 9.63-Mev state. Similar sharp angular correlations were observed in the reaction $F^{19}(\alpha,2\alpha)N^{15}$, but the analysis was complicated by the close level spacing in $F^{19}$. In both of these reactions, there appeared to be no evidence for the giant peaks reported by Donovan et al. in the study of the $O^{16}(\alpha,2\alpha)C^{12}$ reaction. (auth)

**33098** LIFETIMES OF LEVELS IN $Ne^{21}$. R. D. Bent, J. E. Evans, G. C. Morrison, and I. J. Van Heardon (Atomic Energy Research Establishment, Harwell, Berks, Eng.). 14p. (CONF-62-10)

From Conference on Reactions Between Complex Nuclei, Asilomar, Calif., Apr. 1963.

Lifetimes of low-lying levels in $Ne^{21}$ were measured by the Doppler-shift attenuation method using 24-Mev $O^{16}$ ions in the reaction $Be^9(O^{16},\alpha\gamma)Ne^{21}$. The mean lifetimes of the 1.74, 2.80, and 2.87-Mev levels were found. The results are discussed in terms of the unified model. (auth)

**33099** POPULATION OF MAGNETIC SUBSTATES BY INELASTIC $\alpha$-PARTICLE SCATTERING. W. W. Eidson and J. G. Cramer, Jr. (Indiana Univ., Bloomington). 13p. (CONF-46-32)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

When an even-even nucleus is excited to a $2^+$ state by inelastic $\alpha$-particle scattering, restrictions are placed on the population of magnetic substates. If the quantization axis is taken as the direction perpendicular to the reaction plane, population of the m = ±1 magnetic substates is forbidden, as demonstrated by the reflectional symmetry theorem of Bohr. A $\gamma$-ray transition from such a state to the ground state will be pure electric quadrupole and have the same m value as the excited state. Therefore, since the m = 0 electric quadrupole radiation field has 0 amplitude in the reaction plane, the relative population of m = 0 and m = ±2 substates can be determined from the intensity of de-excitation $\gamma$ rays in the reaction plane. This population ratio was studied as a function of $\alpha$-particle scattering angle for the first excited states of $C^{12}$ and $Mg^{24}$, using a 22.5-Mev $\alpha$-particle beam and particle-$\gamma$ coincidence techniques. These population ratios show variations with angle that show some correlation with variations of the elastic and inelastic differential cross sections. (auth)

**33100** ON THE NATURE OF EFFECTIVE NUCLEAR INTERACTIONS IN OXYGEN ISOTOPES. S. P. Pandya (Univ. of California, Los Angeles). 32p. (CONF-46-53)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

The energy level spectra of $O^{17}$, $O^{18}$, $O^{19}$, and $O^{20}$ are analyzed in the framework of the nuclear shell model. The matrix elements of the effective interaction in various two-particle states are deduced. It is shown that the singlet even interaction is not only short-ranged and attractive, but also contains a strongly repulsive central region. This demonstration of a repulsive non-singular core is the essential conclusion. It is also suggested that it may not be possible to represent the effective triplet odd interaction by a simple central potential. An experimental determination of the $3^+$ state in $O^{18}$ would throw further light on this question. The excitation energy of this state is predicted. (auth)

**33101** ELASTIC AND INELASTIC SCATTERING OF $\alpha$ PARTICLES FROM $O^{16}$, $Mg^{24}$, AND $Si^{28}$. J. G. Cramer, Jr. and W. W. Eidson (Indiana Univ., Bloomington). 8p. (CONF-46-52)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

Differential cross sections were measured for elastic scattering of $\alpha$ particles from $O^{16}$, $Mg^{24}$, and $Si^{28}$, using 22.5-Mev $\alpha$ particles. SCAT-IV optical-model fits were obtained for these data and evidence derived from the fits indicates that the observed backward angle peaking is at least partially explained by optical-potential focusing. Differential cross sections were also measured for inelastic scattering to the first 5 excited states of $O^{16}$ and $Mg^{24}$ and the first 4 excited states of $Si^{28}$. However, doublets at 6.05–6.13, and 6.92–7.12 Mev in $O^{16}$, 4.12–4.23 Mev in $Mg^{24}$, and 4.61–4.97 Mev in $Si^{28}$ were unresolved and require special interpretation. Evidence for excitation of the 4.97-Mev state in $Si^{28}$ indicates that it has positive parity, since $(\alpha,\alpha')$ excitation of a $0^-$ state is rigorously forbidden. The phase relationships of the differential cross sections are discussed, along with their bearing on the band structure of the nuclei and the excitation modes of unnatural-parity states. (auth)

**33102** HYPERFINE INTERACTION IN ATOMIC LITHIUM. Frederick J. Milford and Van E. Wood (Battelle Memorial Inst., Columbus, Ohio). 17p. (CONF-23-13)

From American Physical Society Meeting, St. Louis, Mar. 1963.

The net electronic spin density at the nucleus of atomic lithium in its $S^2$ ground state is calculated by an unrestricted Hartree-Fock method using a wave function that involves two independent $S^2$ functions. It is shown that the significance of calculations of this spin density is difficult to assess because of the strong dependence of the results on details of the wave function and that the attribution of any particular amount of improvement over ordinary Hartree-Fock results, in similar calculations, to the inclusion of core polarization effects is difficult to justify. Other calculations of this quantity are discussed briefly. (auth)

**33103** THE $He^3(\alpha,\gamma)Be^7$ REACTION. P. D. Parker and R. W. Kavanagh (California Inst. of Tech., Pasadena). 21p. (CONF-22-11)

From American Physical Society Annual Meeting, New York, Jan. 1963.

The $He^3(\alpha,\gamma)Be^7$ reaction was investigated using gaseous helium targets behind thin nickel foils and using monoenergetic alpha-particle beams with energies from 0.42 to 5.80 Mev. The prompt gamma rays were detected using NaI(Tl) scintillation spectrometers, and the resulting pulse-height spectra were analyzed to determine both the total capture cross section and the branching ratio between the cascade and the crossover transitions as functions of energy. These cross-section measurements were used to obtain a new value for the zero-energy intercept of the cross-section factor, S(E), for this reaction: $S_0 = 0.47 \pm 0.05$ kev-barns, and $(dS/dE)_0 = -2.8 \times 10^{-4}$ barns. (auth)

**33104** A DIRECT-CAPTURE MODEL FOR THE $He^3(\alpha,\gamma)Be^7$ AND $T(\alpha,\gamma)Li^7$ REACTIONS. T. A. Tombrello and P. D. Parker (California Inst. of Tech., Pasadena). 29p. (CONF-22-9)

From American Physical Society Annual Meeting, New York, Jan. 1963.

Using the $He^3$ + $He^4$ scattering phase shifts, the cross section for the $He^3(\alpha,\gamma)Be^7$ reaction is calculated on the basis of a $He^3$ + $He^4$ model for the ground state and first excited state of $Be^7$. Capture of particles from the S, P, D, and F-partial waves by means of E-1, M-1, and E-2 transitions is considered. The results are in excellent agreement with previous experimental data and indicate that the reaction proceeds chiefly by means of E-1 capture from the S and D-waves. It is a surprising consequence that the D-wave contributes an appreciable fraction of the total capture cross section for alpha-particle energies as low as 1 Mev. Using the same values for the reduced widths of the final states that were determined for the $He^3(\alpha,\gamma)Be^7$ reaction, similar calculations also yielded excellent agreement with the experimental data for both the branching ratio and the total cross section of the mirror reaction, $T(\alpha,\gamma)Li^7$. (auth)

**33105** REACTIONS PRODUCED BY $B^{10}$ + $\alpha$ IN THE REGION FROM 4 TO 11 Mev. R. D. Edge (Univ. of South Carolina, Columbia and California Inst. of Tech., Pasadena). 14p. (CONF-22-17)

From American Physical Society Meeting, New York, Jan. 1963.

An investigation of the reactions $B^{10}(\alpha,p;\alpha,d;\alpha,n)$ was made by bombarding a thin separated (96 per cent) $B^{10}$ target with $\alpha$ particles from the tandem Van de Graaff generator. Charged particles were detected by three surface barrier counters at 90°, 135°, and 160° to the incident beam and the neutrons by a long counter at 90° to the beam. The proton groups for the ground state transition and to the first three excited states in $C^{13}$ were observed, and the excitation function was obtained from 4 to 11 Mev. The resonance at 4.6 Mev appeared to be double. Many fluctuations were seen above this energy, all being considerably smaller though broader than the 4.6-Mev resonance. (auth)

**33106** PHOTOMESON STUDIES OF NUCLEAR SIZES. R. A. Schrack (National Bureau of Standards). 27p. (CONF-46-56)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

The use of neutral pion photoproduction to measure nuclear sizes is discussed. The photoproduction process is examined, and analysis of the data is explained. Results show that the technique may be very useful for measuring matter distribution in nuclei. (D.C.W.)

**33107** REACTIONS INDUCED BY THE ALPHA PARTICLE BOMBARDMENT OF $B^{11}$. R. D. Edge (California Inst. of Tech., Pasadena). 14p. (CONF-22-18)

From American Physical Society Meeting, New York, Jan. 1963.

Alpha particles from the tandem Van de Graaff generator were used to bombard a $B^{11}$ target on a copper backing in steps of 16.6 or 33.3 kev from 6.5 to 10 Mev. The energy spectra of the charged particles from the reaction were found by using lithium drifted silicon surface barrier detectors, placed at angles of 90, 135, and 160° to the beam. Neutrons were detected by a long counter at 0°, and low energy gamma rays by a 3 × 3 in. NaI(Tl) crystal-photomultiplier setup at 135°. (auth)

**33108** THE OPTICAL MODEL IN NUCLEAR AND PARTICLE PHYSICS. P. B. Jones. Interscience Tracts on Physics and Astronomy, No. 14. New York, Interscience Publishers, 1963. 123p. $4.50.

The application of the optical model to giant resonances is detailed. Derivations of the optical model on the basis of expansions of the scattering amplitude in powers of the strength of the nucleon-nucleon potential and on the dispersion formalisms for nuclear and potential scattering are given. The properties of the model at intermediate and high nucleon energies, and the use of the model in analyses of nuclear sizes and structures, are summarized. Elastic scattering in the optical model is studied. (T.F.H.)

**33109** RADIOCHEMICAL STUDIES OF SPONTANEOUS FISSION OF $U^{238}$. N. M. Rao. Thesis, Cologne, Universität, 1962. 89p. $2.00.

The mass distribution of spontaneous fission products from $U^{238}$ is investigated. The fission yield of several fission products ($Sr^{89}$, $Sr^{90}$, $Zr^{97}$, $Cs^{138}$, and $Ba^{139}$) was determined by radiochemical separation. Very selective radiochemical separation methods were developed for this purpose. The following cumulative fission yields were measured: $Sr^{89}$: 3.9; $Sr^{90}$: 6.0; $Zr^{97}$: 5.8; $Cs^{138}$: 7.7; $Cs^{139}$: 6.9; and $Ba^{139}$: 6.8. The independent fission yields for spontaneous $U^{238}$ fission are calculated. The results indicate that the neutron evaporation model is also valid for heavy fission products. (Gmelin Inst.)

**33110** TRITIUM PRODUCTION BY NEUTRON-IRRADIATION OF ALUMINUM–LITHIUM ALLOY. Bernard M. Abraham (to U. S. Atomic Energy Commission). U. S. Patent 3,100,184. Aug. 6, 1963.

A process for preparing tritium by neutron-bombarding aluminum–lithium alloy and heating the alloy for the release of the tritium formed is described. (AEC)

## Particle Accelerators

*Refer also to abstract 32917.*

**33111** (CONF-125-1) THE CHOICE OF BETATRON OSCILLATION FREQUENCIES IN A SPIRAL SECTOR FFAG ACCELERATOR. G. Parzen and P. Morton (Midwestern Universities Research Assn., Madison, Wis.). [Apr. 1963]. Contract [AT(11-1)-384]. 25p.

From Sector-Focused Cyclotron and Meson Factory Conference at CERN, Geneva, Apr. 1963.

In a fixed-field alternating-gradient (FFAG) accelerator, the stability limits and the stability of the machine against field perturbations is very much affected by the choice of the betatron oscillation frequencies, $\nu_r$ and $\nu_z$. A general criterion for the stability of the accelerator is proposed, and using this criterion, a computer study was carried out on the dependence of the stability on $\nu_r$ and $\nu_z$. The results of this stability survey seem to indicate a relatively unique choice of $\nu_r$ and $\nu_z$ to obtain the desired beam intensity. (auth)

**33112** [CONF-125-2) DESIGN OF A 720 Mev PROTON FFAG ACCELERATOR. F. T. Cole, G. Parzen, E. M. Rowe, S. C. Snowdon (Midwestern Universities Research Assn., Madison, Wis.), K. R. MacKenzie, and B. T. Wright (California. Univ., Los Angeles). [June 1963]. Contract [AT(11-1)-384]. 25p.

From Sector-Focused Cyclotron and Meson Factory Conference at CERN, Geneva, Apr. 1963.

An FFAG accelerator has advantages for use as a "meson factory," for the production of intense pion beams. The greatest advantage is the flexibility in duty factor arising from beam stacking. Beams can be brought onto targets with duty factors varying from $10^{-6}$ to unity, for use

with different detectors. A conceptual design of an FFAG accelerator was carried out. It is estimated that this design will accelerate more than $10^{15}$ protons per second to an energy of 720 Mev. (auth)

**33113** (CONF-125-3) DESIGN OF PROTON LINEAR ACCELERATORS FOR ENERGIES UP TO 300 Mev. D. E. Young, R. S. Christian, T. W. Edwards, F. E. Mills, D. A. Swenson, and J. Van Bladel (Midwestern Universities Research Assn., Madison, Wis.). [Apr. 1963]. Contract [AT(11-1)-384]. 12p.

From Sector-Focused Cyclotron and Meson Factory Conference at CERN, Geneva, Switzerland, April 1963.

Extension of the conventional $2\pi$ structure for particle acceleration to 200 Mev or higher requires minimization of power losses by optimizing cavity and drift-tube parameters. Using a previously developed method, an optimization of the cavity drift-tube dimensions was made at 200 Mc and at energies of 50, 100, 150, and 200 Mev to give minimum power losses for cylindrical tubes. Drift tubes of other shapes may reduce observed high-energy power losses due to currents in the drift-tube surface. Ellipsoidal tubes appear more efficient than the cylindrical tubes. (D.C.W.)

**33114** (CONF-125-4) USE OF A 10 Gev HIGH INTENSITY ACCELERATOR AS A PION FACTORY. F. T. Cole and A. Galonsky (Midwestern Universities Research Association, Madison, Wis.). [Apr. 1963]. Contract [AT(11-1)-384]. 3p.

From Sector-Focused Cyclotron and Meson Factory Conference at CERN, Geneva, Switzerland, Apr. 1963.

The use of an FFAG 10-Bev high-intensity proton accelerator to produce pion beams of energy below 500 Mev was studied. A statistical model was used to calculate pion yields for this accelerator operating at a time-average intensity of 30 $\mu$amp, and the results were compared with yields for an 800-Mev proton accelerator at 100 $\mu$amp. The 10-Bev accelerator was found to give beam intensities comparable to pion factories and due to its flexibility of duty factor, large $\pi^-$ flux, simultaneous utility at higher energy, etc., was deemed a suitable alternative to the factory. (D.C.W.)

**33115** (CONF-125-5) SPIRAL SECTOR FFAG MAGNET DESIGN AND FIELD MEASUREMENT. S. C. Snowdon, R. S. Christian, G. del Castillo, and R. W. Fast (Midwestern Universities Research Assn., Madison, Wis.). Apr. 1963. Contract [AT(11-1)-384]. 5p.

From Sector-Focused Cyclotron and Meson Factory Conference at CERN, Geneva, Switzerland, April, 1963.

Design of magnets to obtain the required fields is discussed, and calculations by iterative computer techniques of the fields of two magnets are compared with field measurements made with a rotating coil and digital voltmeter system. The results show that the method used to obtain a spiral sector FFAG magnetic field can be made to yield fields that are within a few tenths of a per cent of the calculated fields. (D.C.W.)

**33116** (LNF-63/10) IMPIANTO A RADIO FREQUENZA A 73.6 MHz PER L'ANELLO DI ACCUMULAZIONE ADA. (73.6-MHz Radiofrequency Installation for the AdA Storage Ring). Note No. 186. D. Fabiani and M. Fascetti (Italy. Comitato Nazionale per l'Energia Nucleare. Laboratori Nazionali, Frascati). Feb. 28, 1963. 28p.

A radiofrequency installation containing a generator, a power amplifier, and a resonator for 73.6 Mc was constructed for the AdA storage ring. The installation was constructed for stable voltage and frequency for long periods, supply with single command on a 1-Mc band, power variation within very wide limits, resonator thermal and mechanical stability, and easy operation and maintenance. Detailed pictures and circuits of the complete installation and performance graphs are given. (J.S.R.)

**33117** (LNF-63/18) TEORIA LINEARE DELLE MACCHINE ACCELERATRICI. PARTE II. CALCOLO DELLE COSTANTI DI SMORZAMENTO DELLE OSCILLAZIONI ORIZZONTALI NELLE MACCHINE CIRCOLARI A FOCHEGGIAMENTO FORTE. (Linear Theory of Accelerators. Part II. Calculation of the Damping Constants of the Horizontal Oscillations in Strong-Focusing Circular Accelerators). Note No. 190. G. Sacerdoti and F. Uccelli (Italy. Comitato Nazionale per l'Energie Nucleare. Laboratori Nazionali, Frascati). Mar. 28, 1963. 11p.

The damping constants of betatron and synchrotron oscillations are calculated with a perturbation method for a closed magnetic structure, regardless of its complexity. The results obtained agree with previous results, but the procedure used shows some previously unknown limitations on the validity of the results. (tr-auth)

**33118** (ORNL-TM-643) OAK RIDGE ISOCHRONOUS CYCLOTRON INFORMATION GUIDE FOR USERS. (Oak Ridge National Lab., Tenn.). July 1963. Contract W-7405-eng-26. 12p.

Information on the availability of the research facilities at the cyclotron, on the procedures developed to facilitate their use, on the nature of the facilities, and on the charges for using them is included. (D.C.W.)

**33119** (UCRL-7408) HIGH-CURRENT LINEAR INDUCTION ACCELERATOR FOR ELECTRONS. N. C. Christofilos, R. E. Hester, W. A. S. Lamb, D. D. Reagan, W. A. Sherwood, and R. E. Wright (California. Univ., Livermore. Lawrence Radiation Lab.). [1962]. Contract W-7405-eng-48. 19p. (CONF-114-2)

From International Conference on High Energy Accelerators, Dubna, Aug. 1963.

A 200-amp, 4-Mev electron accelerator was designed and constructed for use in the Astron experiment. Design requirements include a beam quality less than $10^{-2}$ rad-cm and an energy spread of $\pm 0.5\%$; the pulse length is 0.25 $\mu$sec and the repetition rate is variable to a maximum of 60/sec. The accelerating principle used is magnetic induction. Design features and the results of preliminary operation are discussed. (auth)

**33120** (UCRL-10866) BEVATRON IMPROVEMENTS. Edward J. Lofgren and Walter D. Hartsough (California. Univ., Berkeley. Lawrence Radiation Lab.). July 1963. Contract W-7405-eng-48. 17p. (CONF-114-1)

From Proceedings for the International Conference on High Energy Accelerators, Dubna, Aug. 1963.

A completely new injection system was built. This system includes a 480-kev preinjector with a VonArdenne-type ion source, a 19-Mev strong-focusing linear accelerator, and an achromatic inflection system. The radio-frequency acceleration system of the Bevatron was changed to improve reliability, to eliminate beam-induced resonances, and to accommodate increased beam loading. Phase and radius feedback were incorporated into the beam control system. Changes were also made in the magnet power supply, the most important of which was provision for flat-topping the Bevatron magnetic field. The Bevatron was completely enclosed in shielding with 3-m thick walls and a 2.1-m thick roof. A two-magnet proton-beam extraction system was installed. A system of movable targets to operate in the magnet gap and additional beam ports were provided to improve the secondary-beam capability. The

beam is now $2.4 \times 10^{12}$ protons per pulse, about ten times higher than previously with important gains in steadiness. The injector can provide 25 mamp, compared to 0.6 mamp for the old one. (auth)

**33121** (UCRL-10867) HIGH-INTENSITY PHENOMENA AT THE BEVATRON. Glen R. Lambertson (California. Univ., Berkeley. Lawrence Radiation Lab.). July 3, 1963. Contract W-7405-eng-48. 9p. (CONF-114-3)

From International Conference on High Energy Accelerators, Dubna, Aug. 1963.

Present maximum beam intensity at full energy is $2.3 \times 10^{12}$ protons per pulse; this is reached with about 10-mamp injector current. Greater injector current is available, but does not yield an increase in accelerated beam. Amplitude of the initially captured beam reaches a limit of $8 \times 10^{12}$ protons. At this intensity, a spontaneous bunching of the coasting beam appears before rf is applied. This bunching occurs at about the predicted longitudinal space charge limit for growth of perturbations in the coasting beam. At high intensity, the accelerated beam bunches contain more fine structure; also, beam losses during acceleration are greater than at lower beam amplitude. Studies directed toward increasing the intensity are in progress. (auth)

**33122** (UCRL-10868) BEVATRON EXTERNAL PROTON BEAM. William A. Wenzel (California. Univ., Berkeley. Lawrence Radiation Lab.). July 8, 1963. Contract W-7405-eng-48. 21p. (CONF-114-4)

To be presented at International Conference on High Energy Accelerators, Dubna, August 1963.

The achromatic extraction system for the Bevatron proton beam utilizes two separate sets of internal deflecting and focusing magnets, which are plunged into the aperture after injection. The measured vertical emittance of the ejected beam is 30 mrad-mm, in agreement with predictions based upon the size of the energy-loss target, residual betatron amplitude, and Coulomb scattering. As expected, the horizontal emittance is somewhat larger. With the use of external magnets, a focal spot 3 mm vertical by 10 mm horizontal full width at half maximum containing about one-third the circulating beam, was obtained within the main shielding wall of the accelerator. The external transport system now under construction will carry the beam to two additional experimental areas. (auth)

**33123** THE MOTION OF IONS IN THE CENTRAL ZONE OF THE CYCLOTRON. Gr. Indreaş. Acad. Rep. Populare Romine, Studii Cercetari Fiz., 14: 119-26(1963). (In Rumanian)

The motion of ions in the central zone of cyclotrons was studied. The equation of motion was solved by introduction of simplifying hypotheses. The representation of trajectories under various acceleration conditions and different initial geometries permitted the effect of various parameters on the ion motion to be shown. The experimental results agree with the theoretical results. (tr-auth)

**33124** THE EFFECT OF THE BASIC PARAMETERS OF A CYCLOTRON ON THE PHASE AND DURATION OF AN ACCELERATED ION BUNDLE. N. I. Venikov and N. V. Kartashov. At. Energ. (USSR), 14: 521-4(June 1963). (In Russian)

The duration and phase of the external and internal ion beam from a 1.5-meter cyclotron were analyzed by means of graphite probes and an electronic time analyzer having a resolution of ~1.3 manoseconds. The amplitude of the high-frequency voltage between the dees (2U) had only a slight effect on the duration of the ion bundle, but had a significantly greater effect on the phase of the ion bundle. The change in phase $\Delta\phi$ caused by a change in voltage of $2\Delta U$ between the dees is given by the following simplified expression: $\Delta\phi = \cos\phi_0 \left(\sqrt{(2\Delta U/U) - \sin^2\phi_0} - \sin\phi_0\right)$. The amplitude stability is given by the following: $(\Delta U/U) < (\Delta\phi_{allow})^2/2$. Here $\Delta\phi$ is the allowable change in phase. For example, the value of $\Delta U/U$ is equal to $\pm 2 \times 10^{-3}$ at a value of $\Delta\phi_{allow}/2\pi = \pm 1\%$. A change in the magnetic field of 0.01% at the point of exit will change the phase of the exit beam by 1.5 to 2.0% of the period of the high-frequency voltage on the dees. A change in the electric deflecting field $U_{defl.}$ by ±6% from the optimum value decreases the duration of the ion bundle by 25%, and results in a decrease in beam intensity by a factor of 4. The average phase of the ion bundle is given as a function of the radius of acceleration. (TTT)

**33125** AECL TANDEM PROBES INTERIOR OF HEAVY NUCLEI. H. E. Gove (Atomic Energy of Canada Ltd., Chalk River, Ont.). Can. Nucl. Technol., 2: No. 3, 53-6 (1963).

The characteristics of the 12-Mev tandem Van de Graaff accelerator at Chalk River are described briefly. Some of the studies of nuclei using the accelerator are described: nuclear spin measurements of an excited level in $Ne^{20}$, Doppler shift measurements of nuclear lifetimes, studies of fundamental oscillations, etc. The use of computers for data analysis and the future use of the accelerator are considered briefly. (D.L.C.)

**33126** MODIFICATIONS IN THE POST-ACCELERATION PULSING SYSTEM OF TEXAS NUCLEAR NEUTRON GENERATOR. E. Friedman and S. Gorni (Hebrew Univ., Jerusalem). Nucl. Instr. Methods, 23: 155-6(May 1963). (In English)

Modifications were made in the pulsing system of the generator in order to lower the relative neutron background from the target. These modifications consisted of introducing an additional set of deflection plates and pulsing the voltage between these plates. In this way, the background was lowered from $10^{-2}$ to $3 \times 10^{-5}$ even when using high currents. (D.L.C.)

**33127** CLASSICAL RADIATION DAMPING IN ACCELERATORS. F. E. Mills (Centre d'Etudes Nucleaires, Saclay, France). Nucl. Instr. Methods, 23: 197-202(June 1963). (In English)

The rates of change of the adiabatic invariants are calculated in the case of Hamiltonian system subject to generalized nonconservative forces. The results are applied to the classical radiation of electrons in an accelerator or storage ring. The resulting expressions for the damping rates of three independent oscillation modes suggest structures that have damping effects in all three modes, while at the same time allowing "strong focusing" and the attendant strong momentum compaction. (auth)

**33128** A FIXED-FREQUENCY, FIXED-FIELD, HIGH-ENERGY ACCELERATOR. F. M. Russell (Oak Ridge National Lab., Tenn.). Nucl. Instr. Methods, 23: 229-30 (June 1963). (In English)

The concept of a fixed-frequency, constant-magnetic-field accelerator capable of accelerating protons to energies in the Bev region and embodying the principle of strong focusing is described. By designing the magnetic field so that the turns of the "equilibrium orbit" are separated axially as well as radially, as in a helix of expanding radius, it is possible to avoid most of the resonances associated with alternating-gradient systems. Since the focusing properties can be changed discontinu-

ously at chosen points along the orbit, the residual coupling and error resonances do not present severe restrictions; they can be bypassed. Longitudinal stability is also present since the system exhibits phase stability. Injection and extraction are easily achieved, and the final energy can be varied by extracting at chosen points along the orbit path. (auth)

**33129** ELECTRON INJECTION INTO A MICROTRON WITH A RESONANT EMITTER IN THE RESONATOR. R. W. Mueller (Universität, Mainz). Nucl. Instr. Methods, 23: 235-6(June 1963). (In German)

A cathode arrangement is described by means of which a highly efficient injection of electrons into a microtron is achieved. It is a part of a resonant circuit coupled to the resonator and oscillating with a suitable phase. The electric field configuration in the reentrance hole of the resonator has a focusing effect on the electrons. (auth)

**33130** A SOURCE OF POLARIZED PROTONS. G. Clausnitzer (Univ. of Minnesota, Minneapolis). Nucl. Instr. Methods, 23: 309-24(June 1963). (In English)

The design, construction, and test of a source of polarized protons for a linear accelerator will be described. The principle used is separation of the spin states $m_J = +\frac{1}{2}$ and $m_J = -\frac{1}{2}$ in a hydrogen atomic beam by deflection in a strong inhomogeneous magnetic field. The selected component ($m_J = +\frac{1}{2}$) passes adiabatically into a weak field region (forming states $F = 1$, $m_F = 1,0$), where it is ionized by electron bombardment. Protons are extracted, accelerated, and scattered from various targets. The asymmetry after a single scattering is measured and allows a determination of the beam polarization, if the analyzing power of the scatterer is known. The source itself produces a direct current of $3 \times 10^{-8}$ amp of protons with a polarization of 15%. (auth)

**33131** EXTENDED DUTY CYCLE FROM THE HARWELL SYNCHROCYCLOTRON. G. L. Salmon (Clarendon Lab., Oxford). Nucl. Instr. Methods, 23: 338-40(June 1963). (In English)

A rotating target is described that increases the extracted proton pulse duration from the synchrocyclotron by a factor of 20. (auth)

**33132** IMPROVING THE DUTY CYCLE OF THE HARWELL SYNCHROCYCLOTRON. G. Huxtable (Atomic Energy Research Establishment, Harwell, Berks, Eng.), P. S. Rogers, and F. M. Russell. Nucl. Instr. Methods, 23: 357-8(June 1963). (In English)

The addition of a separate r-f supply and accelerating electrode to the Harwell synchrocyclotron, and the effects of this electrode upon the duty cycle of the proton beam emitted by the machine, are described. The duty cycle of the beam with the electrode operating is measured as 0.7. (T.F.H.)

**33133** HOT CATHODE CYCLOTRON ION SOURCE WITHOUT FILAMENT. W. Van Genderen (Inst. of Nuclear Physics Research, Amsterdam). Nucl. Instr. Methods, 23: 359(June 1963). (In English)

A cyclotron ion source is described that incorporates a plasma-heated W cathode. The effect of the plasma heating is to increase stability, gas-consumption efficiency, gas ignition characteristics, and beam output over the cold-cathode operation. (T.F.H.)

**33134** ON THE SIMPLE CHARGING OF VAN DE GRAAFF GENERATORS. P. Croitoru. Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 37-45(1963). (In English)

The fundamentals of charging of Van de Graaff generators are outlined, with attention to the charging and charge-collecting systems, sprayed-electric-charge densities, and short-circuit currents. (T.F.H.)

**33135** ON THE CRITERIA FOR THE CHOICE OF PARAMETERS OF THE LINEAR ELECTRON ACCELERATOR. I. Teodorescu, E. Petrascu, and I. Vintan. Rev. Phys., Acad. Rep. Populaire Roumaine, 8: 95-105(1963). (In English)

Optimization of the parameters of linear electron accelerators for given specific applications (e.g., production of x-ray or neutron beams) is discussed. Maximization of the transfer of microwave power to the electron beam is outlined. (T.F.H.)

**33136** NON-ISOCHRONIC PHENOMENON IN ISOCHRONOUS CYCLOTRON. Shou-hsien Fang and K'ai-yueh Ch'ai. Wu Li Hsueh Pao, 18: 669-82(Dec. 1962). (In Chinese)

The effect of betatron oscillations on the revolution frequency of particles in isochronous cyclotrons was investigated. A formula for the relation of the betatron oscillation amplitude to the particle revolution frequency was presented. Analysis of the results indicates that the basic cause bringing about such non-isochronous phenomenon was the increase in the average magnetic field along the radius. The effect of varying the azimuthal magnetic field was negligible. It is noted that the minimum voltage between the D's was amplified by this effect. (tr-auth)

**33137** INVARIANT-GROUP SOLUTIONS FOR SPACE-STATIONARY CHARGED PARTICLE BEAMS. V. A. Syrovoi. Zh. Prikl. Mekhan. i Tekhn Fiz., No. 3, 26-35 (May-June 1963). (In Russian)

The concept of invariant-group solution is analyzed, and a method for obtaining such solutions is offered. Group equation properties for stationary normal singly-charged particles in an arbitrarily oriented external magnetic field are developed for non-relativistic and relativistic cases. (tr-auth)

**33138** TEORIYA I RASCHET LINEINYKH USKORITELEI (Theory and Calculations of Linear Accelerators). Moscow, Gosatomizdat, 1962. 348p.

A series of articles are included on the theory and calculations of linear accelerators developed during 1947–1956. Problems in accelerated particle dynamics are investigated, and various accelerating systems are analyzed and compared. (R.V.J.)

**33139** AUXILIARY EQUIPMENT FOR THE 5 OR 5.5 Mev VAN DE GRAAFF ACCELERATOR (Engineering Materials). (Oak Ridge National Lab., Tenn.). (CAPE-1013)

There are 19 drawings in this package which describe the following components of auxiliary equipment used with the 5 or 5.5 Mev Van De Graaff accelerator at ORNL: pumping system; control console extension frame; water wall; pulley generator; modified lens No. 1; control rod; column top plate; condenser mounting system; gas recycling equipment; and duo-plasmatron lens pulser and buncher. (F.E.S.)

**33140** STORAGE RINGS. Gerard K. O'Neill (Princeton Univ., N. J.). 37p. (CONF-46-33)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

The development of storage rings is discussed. Advantages of such devices are pointed out as well as their limits, requirements, and design and fabrication problems. Information gained by the operation of small electron storage rings is included, and three experiments are proposed for colliding-beam facilities. (D.C.W.)

# Plasma Physics and Thermonuclear Processes

**33141** (AD-410077) RADIATION FROM AN ELECTROMAGNETIC SOURCE IN A HALF-SPACE OF COMPRESSIBLE PLASMA-SURFACE WAVES. Technical Report No. 396. S. R. Seshadri (Harvard Univ., Cambridge, Mass. Cruft Lab.). Mar. 5, 1963. Contract Nonr-1866 (32). 25p. (NR-371-016)

The radiation characteristics of a line source of magnetic current are studied for the case in which the source is situated in a half-space of isotropic, compressible plasma that is bounded on one side by a perfectly conducting, rigid plane screen. In addition to the electromagnetic and plasma space waves, the line source excites a boundary wave. This boundary wave is a coupled wave. It has associated with it both a magnetic field component and the pressure term. This is in contrast to the space waves that can be decomposed into an electromagnetic (EM) mode with no pressure term and a plasma (P) mode with no magnetic field associated with it. The characteristics of this boundary wave are evaluated. The boundary wave propagates for all frequencies, and the power carried by the boundary wave becomes smaller as the frequency is increased. (auth)

**33142** (D1-82-0218) THE STABILITY OF THE POSITIVE COLUMN IN A TIME-DEPENDENT MAGNETIC FIELD. Roy R. Johnson and David A. Jerde (Boeing Scientific Research Labs., Seattle). Dec. 1962. 35p.

The stability of a weakly ionized plasma column in a longitudinal magnetic field containing a small time varying component was investigated, using a macroscopic approach previously developed for a static field. The time dependence of the field was taken to be linear, and its influence on the column given by the presence of the induced azimuthal electric field. A dispersion relation was derived from the linearized equations of continuity and momentum conservation for the ions and electrons, from which a family of stability boundary curves in the $E_z$ vs. B plane were found for the case of a helical perturbation in helium. The condition of energy balance of the column including the azimuthal electric field was combined with the despersion relation to yield a family of stability boundary curves in the $E_\theta$ vs. B plane with gas pressure times tube radius as a parameter. These curves indicated regions of stability which were absent in the case of a static magnetic field. (auth)

**33143** (D1-82-0229) THERMAL CUTOFFS OF THE WHISTLER MODE OF PROPAGATION. Harold B. Liemohn (Boeing Scientific Research Labs., Seattle). Mar. 1963. 10p.

Recent theoretical analysis of the thermal damping of right-hand circularly-polarized electromagnetic waves propagating along a static magnetic field (whistler mode) in hot plasmas that have (Cauchy) velocity distributions of the form $(v^2 + a^2)^{-3}$ was extended in order to compare the results more directly with experiments. The dispersion equation has a simple algebraic form which can be solved for all frequencies including cyclotron resonance. A thermal Doppler shift in the cyclotron resonance attenuates the mode below the zero-temperature resonance and produces an effective cutoff experimentally. For a given thermal damping decrement in a magnetic field, curves were obtained that relate the "cutoff frequency" to the electron density and temperature of the plasma. The results are compared with previous numerical analyses using the Maxwell distribution and with measurements of the thermal shift of the cutoff in a microwave experiment. (auth)

**33144** (D1-82-0255) LONG WAVELENGTH CHARGE OSCILLATIONS OF A CYLINDRICAL PLASMA. Richard A. Gerwin (Boeing Scientific Research Labs., Seattle). June 1963. 21p.

A cylindrical plasma was assumed in an infinitely strong axial magnetic field. Taking only longitudinal temperature into account, a dispersion relation (including Landau damping) was calculated for electron charge oscillations whose wavelengths are much larger than the plasma radius. The Landau damping was found to be far larger than that of waves in an infinite plasma of the same density and temperature, and for the same wavelength. The radiation damping of these oscillations was also calculated. It was found that these oscillations do not radiate at all from an infinitely long cylinder. For a plasma cylinder of finite length it was found that the radiation damping of these oscillations can be made negligible compared to Landau damping for reasonable laboratory parameters. It was assumed throughout that the unperturbed state is a Maxwellian velocity distribution. (auth)

**33145** (MATT-157) DECREASE OF PLASMA LOSS IN A STELLARATOR RESULTING FROM A PROBE-IMPOSED RADIAL ELECTRIC FIELD. J. G. Gorman and L. H. Th. Rietjens (Princeton Univ., N. J. Plasma Physics Lab.). Feb. 1963. Contract AT(30-1)-1238. 19p. (CONF-38-3)

From American Physical Society Meeting, Atlantic City, Nov.-Dec. 1962.

Current-voltage characteristics of simple, wire-type Langmuir probes were obtained as a function of position and time in the nearly fully ionized hydrogen plasmas of the B-3 stellarator. The magnetic confining field ranged up to 38 kgauss, the plasma density to $2 \times 10^{13}$ per cc and the conductivity temperature to 5 ev. Well-defined saturation current densities were found for both ions and electrons in the ratio of about 1 to 30. The probe data yield electron temperatures proportional to the conductivity temperatures and plasma densities proportional to the microwave-determined densities. If a sufficiently large electron current is collected by a probe, a radial electric field as high as 300 v/cm can be induced in the plasma. The experimental data suggest that a plasma capacitor is established having a magnetic surface as the inner plate, the discharge tube as the outer plate and the plasma as a dielectric. For this potential distribution, a diffusion coefficient $D = 1.3 \pm 0.3 \times 10^3$ cm$^2$/sec was found for the outer region for a 4 ev plasma in a 38 kgauss confining field. If the loss in the inner region, where no radial electric field exists, can be described by diffusion, the diffusion coefficient would be at least eight times greater. Alternatively the high mixing rate in the inner region of this low temperature plasma may be caused by a drift. Both computations and experiments show that a twofold increase in the confinement time of the plasma can be obtained by enlarging the outer region in which the radial electric field is established. (auth)

**33146** (MATT-169) SOME NEW RESULTS ON THE QUASI-LINEAR THEORY OF PLASMA INSTABILITIES. E. Frieman, S. Bodner, and P. Rutherford (Princeton Univ., N. J. Plasma Physics Lab.). Dec. 14, 1962. Contract AT(30-1)-1238. 27p. (CONF-46-36)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

The quasi-linear theory of plasma oscillations developed by Drummond and Pines, and Vedenov, Velikhov and Sagdeyev is examined in detail using the Bogoliubov-Krylov technique of nonlinear mechanics. For the particular case

treated, the mode coupling terms that were neglected in earlier work are of the same order of magnitude as those kept. The asymptotic time development of the system is also discussed in detail. (auth)

**33147** (MATT-198) LONG WAVELENGTH INSTABILITY IN A REFLEX DISCHARGE. Robert Bingham (Princeton Univ., N. J. Plasma Physics Lab.). May 1963. Contract AT(30-1)-1238. 25p. (CONF-46-30)

From American Physical Society, Washington, D. C., April 1963.

An examination of the stability of the reflex arc (P.I.G.) discharge against a long wavelength m = 1 instability was carried out. In performing the calculation, use was made of the experimental plasma density distribution and the plasma potential distribution as computed by Chen for a hot cathode P.I.G. in a strong magnetic field. It was found that the discharge is unstable for helical instabilities with wavelength greater than 1200 R cm, where R is the discharge radius. The growth rate increased with increasing wavelength. This result was consistent with that of Simon's analysis of a slab geometry with crossed electric and magnetic fields. (auth)

**33148** (NASA-TN-D-1875) RESONANCE IN A COLD MULTICONSTITUENT PLASMA AT ARBITRARY ORIENTATION TO THE MAGNETIC FIELD. Eli Reshotko (National Aeronautics and Space Administration. Lewis Research Center, Cleveland). July 1963. 25p. (N63-18652)

The sensitivity of resonant frequency to the orientation of the propagation vector was examined for plasmas having both single and multiple ion species. For propagation at right angles to the magnetic field, the hybrid resonances of Auer, Hurwitz, and Miller and of Buchsbaum are obtained. However, at high plasma density, if the direction of the propagation vector departs even slightly from 90°, each of these resonances shifts quickly to a higher frequency approaching the next single species cyclotron frequency, and an additional resonance appears at a frequency below the lowest single species cyclotron frequency. In the limit of high plasma density, all the aforementioned resonances have the common property that there is no net current in the direction of the electric field. (auth)

**33149** (NBS-7919) ON THE CRYOGENIC ASPECTS OF PROJECT SHERWOOD. Fourteenth Progress Report, April 1, 1963 to June 30, 1963. (National Bureau of Standards. Boulder Labs., Boulder, Colo.). June 30, 1963. 7p.

The vacuum system was modified by a shutter arrangement to allow simultaneous deposition of films of different thickness on the same substrate. Machine calculations indicated that Gorkov's result for the magnitude of the critical supercooling magnetic field at absolute zero is accurate to about 1%. Construction of the superconducting Helmholtz pair continued. The Al magnet coil arrangement was modified after magnetic pressure warped some of the coil lobes. The coolant pump capacity was increased after calculations and experience showed the maximum field was only 72 kgauss; 100 kgauss should now be possible. The turbine expander was tested with the redesigned expander nozzle and rotor and the low pressure bearings at a 4 to 1 expander ratio. An expander efficiency of 80% was achieved, and improved shaft balancing permitted shaft speeds of 660,000 rpm. The externally pressurized gas-lubricated bearings performed satisfactorily. (D.C.W.)

**33150** (ORNL-3472) THERMONUCLEAR DIVISION SEMIANNUAL PROGRESS REPORT FOR PERIOD ENDING APRIL 30, 1963. (Oak Ridge National Lab., Tenn.). Aug. 7, 1963. Contract W-7405-eng-26. 140p.

Progress in various aspects of thermonuclear research is reported. Separate abstracts were prepared for ten of the twelve sections of the report. Design and engineering service notes and a report list are given in the remaining sections. (D.C.W.)

**33151** (ORNL-3472(p.1-8)) DCX-1 PLASMA EXPERIMENTS. J. L. Dunlap, R. S. Edwards, et al. (Oak Ridge National Lab., Tenn.).

The configuration of the DCX-1 facility and the basic operating parameters remained relatively unchanged: the base operating pressure is normally still low in the $10^{-9}$-torr range; the maximum $H_2^+$ beam is about 10 ma; and the maximum trapped-proton density is about $10^8/cm^3$. The longest containment time measured is 57 sec, registered by a detector on the median plane. The studies of correlations between plasma parameters and radio-frequency signals were extended, and more evidence was obtained on the influence of the ion-clumping instability on the Z extent of the plasma. Several techniques by which the plasma might be partially stabilized against the instability were investigated, but only slight increases in plasma density were noted. The effects of deliberate perturbations of the magnetic field were studied, and it was concluded that the containment properties of the facility were insensitive to the slight errors in magnetic-field shape that are now present in normal operation. The rates of proton trapping by the Lorentz dissociation of $H_2^+$ were investigated for $H_2^+$ obtained in the conventional manner (directly from a duoplasmatron source) and for $H_2^+$ obtained by dissociating an $H_3^+$ beam in the water-vapor cell. There was no evidence of Lorentz trapping of the beam formed by the first procedure (the observations fixed the Lorentz trapping fraction as less than $10^{-7}$), but a substantial fraction ($5 \times 10^{-5}$) of $H_2^+$ formed from $H_3^+$ was found to be trapped by this mechanism. (auth)

**33152** (ORNL-3472(p.9-23)) DCX-2. P. R. Bell, L. J. Bledsoe, et al. (Oak Ridge National Lab., Tenn.).

Experiments involving dissociations on the background gas were carried out at pressures as low as $7 \times 10^{-7}$ mm Hg and with total beam currents generally up to 75 ma. From the neutral flux leaving the plasma, the energetic-particle density inside is generally in the range $10^6$ to $10^7$, with lifetimes in the range of 5 msec. By use of a faster amplifier, the initial decay of the neutral current could be examined and was found to be in the range of several hundred microseconds. Energy spectra of the escaping neutral flux show both wide energy and angular spread of the trapped protons. Energy half-widths of the peak due to trapped protons (all expected to be at 300 kev) are approximately 80 kev. The plasma potential was determined after the development of gridded probes that can be used to analyze the energy distribution of particles from the "cold" or "background" plasma. The plasma potential during background-gas dissociation experiments lay between 140 and 540 v. These probes could also be used in such a way as to bias out the "cold" plasma; under these conditions, bursts of fast ions are clearly evident out to radial distances as large as 10 in. Fast particles are not expected past the radial position of the injector, approximately 6 in. from the center, because of the rather rapid expected precession rate due to the radial gradient of the magnetic field near the mirrors. Despite the absence of detailed time correlation between two probes, a general gross correlation does appear to exist, and so the effect of one probe on the other is difficult to assess. Radiofrequency studies were continued, with particular emphasis on trying to establish the phase relation of signals from probes azimuth-

ally and axially displaced in the machine. Once again, difficulty in interpreting the data was encountered as a result of apparent "gross" correlation, but no detailed correlation, between signals on probes. Experiments were carried out to determine if a greater stability of the trapped protons could be effected by potentials on end electrodes or a relatively cold, high-density plasma. The end-electrode potential had a marginal effect. The backstream from a lithium arc seemed to affect the trapped density and significantly reduced the frequency and current of bursts to radial probes. Similar effects were seen with a high-density lithium plasma column. Energy spectra observed in the latter case showed a significantly larger spread in the energy distribution. An electron gun, which could produce currents up to 5 amp at 3 kv in a 3½-in. ring, approximately ⅛-in. thick, was also used to produce a secondary plasma in DCX-2. Radiofrequency studies show intense oscillations, indicating that a beam-plasma interaction has occurred. The trapped density was again approximately $10^7$ protons/cm$^3$. The protons again showed an abnormally large energy spread. A high-speed current amplifier is described that was used with the foil-covered neutral-particle detector to observe the fast decay of the plasma. It has a rise time of approximately 1 μsec, an rms noise figure of $2 \times 10^{-10}$ amp equivalent, and a gain of $10^{-7}$ amp/v. (auth)

**33153** (ORNL-3472(p.24-49)) PLASMA PHYSICS. W. B. Ard, M. C. Becker, et al. (Oak Ridge National Lab., Tenn.).

In the electron-cyclotron heating experiment in the Physics Test Facility, measurements have been made of 4- and 8-mm microwave noise, phase shifts with a 4-mm microwave interferometer, neutral-beam transmission, plasma magnetic field, visible-light emission, x-ray emission, neutron emission, and the current to multigrid probes. Studies of the variation of some of these parameters as a function of 3-cm microwave power and as a function of xenon gas impurity are described. A small-scale, hot-electron plasma generated by the interaction of an electron beam with the plasma of the beam, and contained between magnetic mirrors appears stable. The increased Debye length due to the high temperature may permit independent particle processes. Several experiments that will form hot-electron plasmas of DCX size are being prepared. Preliminary beam-plasma interaction studies in the beta tank indicate the existence of two interaction modes. The first seems to be characterized by ionic oscillations, up to the fifth harmonic of the cyclotron frequency, and the second seems to be characterized by electronic oscillations, as reflected in the x-ray output. Measurements of plasma density and ion temperature and analysis of x-ray spectra have begun. An electron-beam spreader or expander was developed to dissipate the energy in a beam of power density of the order 200 kw/cm$^2$. Tests up to 150 kw/cm$^2$ indicate no apparent wearing on the target. Ionic sound velocity was measured directly in plasmas of the noble gases by a time-of-flight method. An automatic analog computer was constructed to obtain electron temperature directly from Langmuir probe characteristics. (auth)

**33154** (ORNL-3472(p.50-5)) VACUUM ARC RESEARCH. R. A. Gibbons, T. F. Rayburn, et al. (Oak Ridge National Lab., Tenn.).

Ideal-plasma calculations based on previous temperature and density measurements indicated that the plasma space potential, electron temperature, and arc electrode power might be calculated from power balance and calculated plasma particle flows. The resulting calculated electron temperatures are proportional to the arc power and have ranged from 5 to 35 ev for the deuterium arc. A plasma with a calculated temperature of 31 ev yielded a Langmuir-probe electron temperature of 45 ev. The agreement between calculated and measured electrode powers was good over a broad range of arc parameters. The dependence of the observed ion temperatures on the charge state of ions in the gas-fed, magnetically confined, high-current carbon arc is discussed briefly in terms of turbulence phenomena and a possible resonance ion-cyclotron heating mechanism. (auth)

**33155** (ORNL-3472(p.56-69)) CROSS SECTIONS. C. F. Barnett, J. A. Ray, et al. (Oak Ridge National Lab., Tenn.).

The cross section for proton production by $H_2^+$ in $H_2$ gas was remeasured in the energy range 40 to 200 kev. A comparison has been made for the cross sections obtained from $H_2^+$ ions from (1) a radiofrequency source, (2) a PIG source, and (3) $H_3^+$ dissociation. The results agree well with those of other investigators in this energy range. Measurements were made of the fraction of a hydrogen beam that exists in the neutral-charge state after passing $H_3^+$ and $H_2^+$ through hydrogen and water vapor for energies of 60 to 400 kev. The fraction of neutrals formed varied as $Ae^{-B/v}$, where A and B are constants for each gas and $v$ is the particle velocity. Measurements of the $H^0$ spatial distribution indicate a half angle of divergence of 20 milliradians from the dissociation of 60-kev $H_3^+$ in water vapor. Studies of $H_2^+$ ion formation in high vibrational states were completed. $H_3^+$ ions were passed through water vapor in the energy range of 60 to 400 kev. The number of $H_2^+$ ions formed per incident $H_3^+$ ion was 0.14 at 60 kev and decreased to 0.105 at 400 kev. Performance tests on the new metal-gasket-sealed ultra-high-vacuum, 6-in., oil diffusion pumps indicate that a base pressure of $10^{-9}$ torr should be obtainable in the outer region of the crossed-beam high-vacuum chamber with the use of an N.R.C. pump and water-cooled baffle and a pressure of $10^{-10}$ torr in the inner region using cryo-titanium techniques. Tabulated Gaunt factors for the bound-free transitions of atomic hydrogen are used to derive photoionization cross sections for the nth state of atomic hydrogen ($1 \leq n \leq 15$). A modified Bethe approximation is used to convert these to electron-impact ionization cross sections from threshold to 200 ev. For the 1s state the results are in good agreement with experiment, but for the 2s and 2p states the maximum cross section lies about a factor of 4 below the Born approximation calculations. (auth)

**33156** (ORNL-3472(p.70-4)) PRODUCTION, ACCELERATION, AND INJECTION OF IONIC AND ATOMIC BEAMS. R. C. Davis, R. R. Hall, et al. (Oak Ridge National Lab., Tenn.).

The new accelerator tube with epoxy skirts is performing very satisfactorily on the DCX-2 injector system. The 600-kv $H_2^+$ ion current injected into the machine is limited to only 60 ma, although the total current is 150 ma. This same current limitation was found with the High-Intensity Beam Facility. The cause of this current limitation appears to be a decreased relative production of $H_2^+$ in the ion source. The duoplasmatron ion source was evaluated both as a source of $H_3^+$ ions and electrons. Up to 36 ma of $H_3^+$ ions were obtained with a total current of 89 ma. The maximum electron current obtainable was not determined, but 1 amp of electrons was extracted at 20 kv with 0.4 amp arc current. A second electron gun was built and tested up to 1500 v at 5 amp. A neutral source composed of two

hollow-cathode arc discharges, one used as ion source and one as converter, is still undergoing components testing. Some low-voltage insulation problems have arisen, but they are not believed to be serious. Negative chlorine ion clusters have apparently been formed by the pressure-gradient arc (mode II). (auth)

**33157** (ORNL-3472(p.75-83)) PLASMA THEORY AND COMPUTATION. T. K. Fowler, Ya'akov Shima, et al. (Oak Ridge National Lab., Tenn.).

In a simplified discussion of velocity-space instabilities, it is shown that a "bunching" mechanism in response to the continuity condition and energy conservation causes all electrostatic growth of such modes. Further, the pinch effect, responsible for magnetic instabilities, is just a relativistic correction to bunching. A method is presented for obtaining bounds on instability growth rates applicable to spatially nonuniform plasmas not amenable to conventional analysis. The growth rate is found to be small for equilibria near a stable state. For example, the streaming instability growth rate vanishes at least linearly with the streaming speed. Stability of a spatially inhomogeneous plasma column and a slab of finite thickness is discussed. The influence of the shape of the free-electron energy distribution on the steady-state de-excitation radiation resulting from electron collisions with not completely stripped impurity ions was investigated. When the transition energy between impurity levels is large compared with the mean electron energy, the radiation rate is very sensitive, by orders of magnitude, to details of the high-energy tail of the electron distribution. An electron stream passing through an idealized representation of the DCX-1 plasma is found to stabilize the lowest-frequency modes of the Harris type, but it introduces new unstable modes at higher frequencies. For purposes of microwave interferometry, the index of refraction of a very hot electron plasma in a magnetic field, with polarization along the field, was calculated relativistically. It is found that the cold-plasma result is valid for electron energies of tens of kilo-electron volts. Numerical calculations of DCX-1 orbits for $H^+$, $H_2^+$, and $H_3^+$ beams are described. An improvement in the mirror-loss formula in calculating DCX-2 performance curves led to an increase in the predicted critical current. (auth)

**33158** (ORNL-3472(p.84-106)) MAGNETICS AND SUPERCONDUCTIVITY. W. F. Gauster, D. L. Coffey, et al. (Oak Ridge National Lab., Tenn.).

The Gaussian integration code for calculating magnetic properties of current systems and a routine for tracing flux lines were completed. Tests made under well-reproducible thermal-transient conditions showed that the thermal protection of water-cooled magnet coils depends appreciably upon the position of the thermal switch on the coil conductor. An empirical rule for the best location of those thermal switches was found. Improvements were made on the cryostat current-input apparatus described in the last progress report. Newly developed feedthrough insulators proved to be able to withstand repeated exposures to large temperature changes. By use of a precooling nitrogen container with such bushings, the head of the current-input apparatus was completely redesigned and now allows pumping for achieving temperatures below 4.2°K. Experience shows that the current-carrying capacity of high-field superconductor magnet coils is often considerably smaller than that expected from short sample wire tests ("degradation effect"). An analysis of existing theories of the degradation effect is presented, which is also extended to the limiting case of an infinitely long, soft-superconducting solenoid. Experiments with a coil of simulated infinite length show the expected maximum field. Finally, tests have been made on the intermediate state of soft-superconductor coils with and without end compensation. Metallurgical properties of superconducting metals and alloys were studied, and development of micromagnetometers was begun. Fabrication of magnetoresistive Bi magnetometers by vacuum deposition of thin films was examined, and the properties of the thin films were measured. (auth)

**33159** (ORNL-3472(p.107-18)) VACUUM SYSTEMS, TECHNIQUES, AND MATERIAL STUDIES. J. D. Redman, D. M. Richardson, et al. (Oak Ridge National Lab., Tenn.).

Leak-tight sealing of a 99% aluminum alloy wire gasket between plain flange surfaces is dependent on the mechanical properties of the alloy. Although the gasket was limited to a finite number of thermal cycles because of creep, it was possible to maintain vacuum closure for more than 18 thermal cycles between room temperature and 250°C with 4 hr per bake at the elevated temperature. The maximum loading force necessary to remain in the plastic, sealing, region is approximately $8\frac{1}{2}$ tons/in.$^2$, or 3000 lb per linear inch of gasket. Initial sealing of this 0.086-in.-dia. gasket was achieved with approximately 0.028-in. gasket deformation and a force of 1500 lb/linear in. Desorption behavior from a 30,000-cm$^2$ aged molybdenum surface was studied as a function of temperature from 80 to 115°K. Heats of desorption were determined for two desorption peaks found in the pressure-temperature data. Admission of three gases, CO, $CH_4$, and Ar, followed by a thermal adsorption yielded isosteric heats of 3.0, 4.3, and 3.5 kcal/mole. The total quantity of gas desorbed, starting from a base pressure in the range of 2 to $4 \times 10^{-10}$ torr, was found to be a small fraction of a monolayer. An expression for a Henry's law isotherm was derived, and a discussion of sorption speed at low temperatures and other desorption phenomena are discussed with reference to the derived isotherm. (auth)

**33160** (ORNL-3472(p.119-20)) FURTHER SPECULATIONS ON VERY HIGH ENERGY INJECTION INTO A MAGNETIC MIRROR. J. R. McNally, Jr., Mozelle Rankin, and E. D. Shipley (Oak Ridge National Lab., Tenn.).

Calculations on the injection of $H_2^+$ at 3 to 6 Mev into a DCX-1 type device indicate that proton densities two orders of magnitude greater than those presently achieved might be obtained at these energies. The plasma exponentiation condition would also be more easily attainable, but would become hard to maintain as electron density increased. The higher energy would also aid study of instabilities causing a volume increase of the trapped plasma. (D.C.W.)

**33161** (UCRL-10698) INSTABILITY OF AN ALTERNATING-CURRENT POSITIVE COLUMN IN A MAGNETIC FIELD (thesis). Henry F. Rugge (California. Univ., Berkeley. Lawrence Radiation Lab.). Apr. 22, 1963. Contract W-7405-eng-48. 123p.

The positive column of a glow discharge in a magnetic field is known to become macroscopically unstable at some critical magnetic field, $B_c$. Kadomtsev's proposed driving mechanism for this helical (m = 1) instability is such that if one periodically reverses the axial electric field at a frequency greater than the growth rate of the instability, one would expect it to be suppressed. A detailed study of the instability was made in d-c half-wave-rectified (unidirectional) current, and square and sinusoidal a-c glow discharges in $H_2$, $D_2$, He, Ne, and Ar. The study of the d-c discharges corroborated previous results and yielded experimental parameters necessary for com-

parison with theory. Electron-temperature measurements at B = 0 and near the critical magnetic field were obtained by employing single- and double-probe techniques. Half-wave rectified discharges over a wide range of frequencies yielded instabilities whose onset ($B_c$) and helical nature duplicated those of the direct-current discharges. However, the instability in the alternating-current discharges was found to be suppressed as the electric-field reversal frequency was increased; this substantiates the Kadomtsev model of the driving mechanism. The frequency-dependent suppression of the alternating-current instability is compared with the theoretical growth rates. The effect of several m-value modes is calculated, and results show good qualitative agreement. Good quantitative agreement is obtained when the Johnson and Jerde modification of the Kadomtsev theory is employed. 49 references. (auth)

**33162** PARAMETRIC OSCILLATIONS AND HARMONIC GENERATION IN A PLASMA DISCHARGE. G. S. Kino and J. H. Krenz (Stanford Univ., Calif.). Appl. Phys. Letters, 3: 53-5(Aug. 15, 1963).

First observations of parametric oscillations at half the exciting frequency are given for an r-f plasma discharge. The equation of motion for electrons is given considering a system with zero d-c magnetic field and ignoring collisions. (R.E.U.)

**33163** THE PROBLEM OF PLASMA ROTATION. E. P. Velikhov. At. Energ. (USSR), 14: 573(June 1963). (In Russian)

The observation of plasma rotation in a Θ-pinch is explained. The observed angular velocity of the rotation is equal to $\Omega_+ r_{l+}/r^2$ within an order of magnitude, where $\Omega_+$ is the cyclotron frequency of the ion rotation, $r_{l+}$ is the Larmor radius of the ions, and r is the average radius of the plasma. It is shown that in a sufficiently dense plasma, any radial motion of the plasma should result in the appearance of a nonuniform rotation with the above velocity. After writing the hydrodynamic equation for the movement of a hot plasma, it was found that the angular velocity of rotation is as follows: $\Omega \cong (r_{l+}^2 \Omega_+/r^2)(r/l)$, where l is a characteristic measure of the steepest initial or final gradient. Since the velocity $v_y$ is close to the drift velocity of the ions, a plasma moving at this velocity should be near the limit of stability. The angular velocity is sufficient to explain the instability of the plasma column and the rate of plasma rotation in a Θ-pinch. (TTT)

**33164** ELECTRICAL IMPEDANCE OF ELECTRODES IMMERSED IN MOVING PLASMA. P. R. Smy (Univ. of British Columbia, Vancouver). Can. J. Phys., 41: 1346-58(Aug. 1963).

The electrical impedance of two cold electrodes immersed in moving argon plasma has been measured. The plasma is formed by a shock wave moving at $4 - 8 \times 10^5$ cm/sec into argon at an initial pressure of 0.01 – 1 mm Hg. It is found that a pronounced discontinuity in electrode impedance exists under all experimental conditions at electrode voltages in the neighborhood of 50 volts. An appreciable capacitance, which is dependent both on electrode area and on plasma density, is detected in the electrode impedance with electrode voltages of less than about 50 volts. This is ascribed to displacement currents in a sheath at the surface of one or both electrodes. Values of sheath thickness calculated from the observed "capacities" show order-of-magnitude agreement with the calculated plasma Debye length. Since the sheath electric fields corresponding to an electrode voltage of 50 volts and these sheath thicknesses are in the range $10^6 - 10^8$ volts/cm, it is thought that the observed impedance discontinuity arises from the onset of electron emission from the cathode. (auth)

**33165** A SOLUTION OF THE MOTION OF A CHARGED PARTICLE IN MAGNETIC MIRROR SYSTEMS. J. Lacina (Inst. of Vacuum Electronics, Czechoslovak Academy of Sciences, Prague). Czech. J. Phys., 13: 401-17(1963). (In English)

A solution for the motion of a charged particle in an axially symmetrical, magnetostatic field, which forms magnetic mirror systems. The solution is based on the hamiltonian for the motion of a charged particle in such a field. The whole problem is solved in orthogonal curvilinear coordinates, the coordinate curves being formed by the lines of force and the curves perpendicular to them. By applying the perturbation method of multi-periodical systems to the hamiltonian in these coordinates, a hamiltonian is obtained for the motion of the guiding center that contains only the coordinate of motion along the lines of force, the others being cyclic. Thus, in addition to the energy two other first integrals of the equations of motion are obtained, from which the conditions for confinement of motion in a magnetic field are immediately obtained. Since the hamiltonian obtained in this way contains only one coordinate, the whole problem is solved by two quadratures, which define the dependence of the time and azimuthal angle on the line-of-force coordinate, while the other quantities are constant. (auth)

**33166** THE ROLE OF PLASMA INSTABILITIES IN THE ORIGIN OF SOLAR FLARES. R. K. Jaggi (Goddard Space Flight Center, Greenbelt, Md.). J. Geophys. Res., 68: 4429-35(Aug. 1, 1963).

The role of plasma instabilities in the origin of a solar flare is investigated. Three types of stability problems are discussed: the magnetohydrodynamic instability of an infinitely conduction fluid; the instability produced by magnetic field gradients; and finite conductivity instability. These instabilities are examined in a situation that occurs when two plasmas trapped in a pair of sunspot magnetic fields approach each other. The assumption of infinite conductivity gives rise to stable situations. The instability growth time in the magnetic field gradients that exist near sunspots is extremely large. The growth time for finite conductivity instability is of the order of a few seconds or minutes, and it is therefore believed that the flare can be produced by finite conductivity instabilities in the solar atmosphere above a group of sunspots. This analysis does not help explain the acceleration of charged particles to high energies; for this, the problem of acceleration must be considered separately. (auth)

**33167** KINETIC EQUATION FOR AN UNSTABLE PLASMA. R. Balescu (Université Libre, Brussels). J. Math. Phys. (N. Y.), 4: 1009-19(Aug. 1963).

A kinetic equation is derived for the description of the evolution in time of the distribution of velocities in a spatially homogeneous ionized gas that, at the initial time, is able to sustain exponentially growing oscillations. This equation is expressed in terms of a functional of the distribution function that obeys the same integral equation as in the stable case. Although the method of solution used in the stable case breaks down, the equation can still be solved in closed form under unstable conditions, and hence an explicit form of the kinetic equation is obtained. The latter contains the normal collision term and a new additional term describing the stabilization of the plasma. The latter acts through friction and diffusion and brings the plasma into a state of neutral stability. From

there on the system evolves toward thermal equilibrium under the action of the normal collision term as well as of an additional Fokker-Planck-like term with time-dependent coefficients, which however becomes less and less efficient as the plasma approaches equilibrium. (auth)

**33168** MEASUREMENT OF THE TEMPERATURE IN A PIG REFLEX PULSE DISCHARGE WITH A FABRY-PEROT INTERFEROMETER. R. Chabbal (CNRS, Bellevue, France), M. Clement, and R. Geller. Nucl. Instr. Methods, 23: 325-37(June 1963). (In English)

A method is described for measuring ionic temperatures using a Fabry-Perot interferometer. After a description of the gas discharge and an estimate of the order of magnitude of the ion temperatures and lines to be expected, a survey is made of the different types of methods that could be used, which leads to the choice of the Fabry-Perot interferometer. The experimental set-up is described, and results are given concerning the measurements on the discharge. (auth)

**33169** NONLINEAR LANDAU DAMPING OF OSCILLATIONS IN A BOUNDED PLASMA. David Montgomery (Univ. of Maryland, College Park). Phys. Fluids, 6: 1109-14(Aug. 1963).

A previously developed perturbation-theory-to-all-orders formalism is applied to the oscillations of a collisionless electron plasma that is bounded by perfectly reflecting walls. The long-time damping rate is the same for the nth order electric field as for the first order. This result generally does not apply to the unbounded plasma. (auth)

**33170** NONLINEAR STATIONARY WAVES IN RELATIVISTIC PLASMAS. H. S. C. Wang (Univ. of Colorado, Boulder). Phys. Fluids, 6: 1115-23(Aug. 1963).

Theory of nonlinear stationary longitudinal waves in relativistic plasmas is treated by solving a relativistic Boltzmann equation without the conventional approximation of linearization. It is proved that in plasmas of physically reasonable electron velocity distributions, stationary waves of arbitrary amplitude can be propagated and obey a dispersion equation. If the velocity of propagation V is less than the velocity of light c, the amplitude of these waves will generally be limited; if the velocity of wave propagation is greater than c, however, there is no amplitude limitation. The nonlinearity in the Boltzmann equation causes a decrease of frequency of oscillation for a given wave velocity in addition to the distortion in waveform from pure sinusoidal waves. Detailed solutions for plasmas with Maxwellian electron velocity distribution and relativistic electron beams are given. In the former case, a dispersion equation including nonlinear effect is derived through a series expansion to an order higher than that used in the linearized theory. In the latter, a complete analytic solution in terms of elliptical integrals is given. In both cases dispersion characteristics for several parameters are computed and plotted. The agreement between these nonlinear dispersion equations in the limit of vanishing amplitudes and those of the linearized theory published is indicated. (auth)

**33171** PLASMA OSCILLATIONS AND LANDAU DAMPING. Harold Weitzner (New York Univ., New York). Phys. Fluids, 6: 1123-7(Aug. 1963).

The problem of the plane wave oscillation of a one-dimensional plasma is considered. It is shown that for stable plasmas with unperturbed distribution functions in a general class that includes Maxwellians as a special case, the electric field does not damp exponentially fast, as predicted by Landau. Instead, the electric field tends to zero as some reciprocal power of time, where the exact power depends on the smoothness of the initial data. To obtain a more conventional result it is assumed that all distribution functions vanish for particle speed greater than some constant, as they must relativistically. Then for wavenumber less than a certain constant the plasma oscillations do have an undamped part corresponding to a conventional normal mode with a phase speed greater than the fastest particle speed. For wavenumbers larger than that constant the oscillations tend to zero as some reciprocal power of time. (auth)

**33172** PLASMA OSCILLATIONS IN AN EXTERNAL ELECTRIC FIELD. Burton D. Fried and Glen J. Culler (Thompson Ramo-Wooldridge, Inc., Canoga Park, Calif.). Phys. Fluids, 6: 1128-38(Aug. 1963).

The fluctuation longitudinal electric field, $E_k$, is studied for a two component plasma immersed in a uniform, external electric field $E_0$. Since the time dependence of the space-averaged part of the distribution functions precludes the usual Laplace transform approach, computational techniques are developed to solve the integral equation for $E_k$ directly in the time domain. Solutions are given for the case where $E_0$ is large compared to the critical field for runaway and compared with the familiar constant-drift solutions. Growth in the vicinity of resonance is observed, followed by Landau damping at longer times. (auth)

**33173** TWO-PARTICLE CORRELATION FUNCTION FOR AN UNSTABLE PLASMA. P. H. Rutherford and E. A. Frieman (Princeton Univ., N. J.). Phys. Fluids, 6: 1139-44(Aug. 1963). (MATT-175)

The usual kinetic equation derived from the B-B-G-K-Y hierarchy for a plasma with Coulomb interparticle forces breaks down for plasmas with distribution functions that the linearized Vlasov equation would predict to be unstable. As the first step towards deriving a kinetic equation for an unstable plasma the equation for the two-particle correlation function is solved for times for which the distribution function may be regarded as time independent. Part of the correlation function is shown to grow exponentially in time; thus the Bogoliubov adiabatic hypothesis breaks down. Taking only the fastest growing part of the correlation function, a velocity space diffusion equation is obtained for the distribution function with a time-dependent diffusion coefficient. (auth)

**33174** RELAXATION PHENOMENA IN PLASMAS. Richard L. Liboff (New York Univ., New York). Phys. Fluids, 6: 1145-53(Aug. 1963).

The influence of four basic relaxation mechanisms on two-component plasma waves is examined. The analysis stems from a set of generalized macroscopic equations that include two self-relaxation mechanisms in addition to terms that dampen difference in temperatures and difference in flows between the gases. The emergent dispersion relation is diagonal with respect to longitudinal and transverse components of the state vector. The longitudinal relation is linear in the temperature coupling parameter while the transverse relation is independent of the self-relaxation rates and the difference in velocity relaxation rates. The longitudinal determinant yields well-known roots in the limit of long temperature relaxation times, while in the opposite limit new relations are obtained. (auth)

**33175** EFFECT OF RESISTIVITY ON HYDROMAGNETIC INSTABILITIES IN MULTIPOLAR SYSTEMS. John L. Johnson, John M. Greene, and Bruno Coppi (Princeton Univ., N. J.). Phys. Fluids, 6: 1169-83(Aug. 1963).

The effect of electrical resistivity on hydromagnetic instabilities is studied with special emphasis on interchange

instabilities. A stellarator expansion is utilized to reduce the stability problem to one of solving two coupled second-order ordinary differential equations. This expansion enables one to treat a general geometry in a simple manner. A low-pressure strongly stabilized pinch is one special case. Further expansions are made in which perturbations vary rapidly in a thin layer the width of which is related to the resistivity. Highly localized interchange instabilities are found with growth rates that are independent of the resistivity in the limit as it goes to zero. These exist whenever the pressure decreases outwards. Interchanges with eddies of finite length grow more slowly, as the cube root of the resistivity. A stability criterion for kink modes, which are characterized by vanishing pressure gradients in the resistive layer, is obtained. It depends on the entire plasma configuration and is identical to the one that would be obtained from the energy principle if the resistive layer were replaced with a vacuum. Gyration radius effects that are not included may significantly affect these resistive instabilities because they have slow growth rates and vary rapidly in a localized region. (auth)

**33176** INSTABILITY OF PENNING-TYPE DISCHARGE. F. C. Hoh (Royal Inst. of Tech., Stockholm and General Atomics Div., General Dynamics Corp., San Diego, Calif.). Phys. Fluids, 6: 1184-91(Aug. 1963).

It is shown that a weakly ionized plasma column in an axial magnetic field and an inward-directed radial electric field—a Penning discharge at higher pressures—is unstable against a macroscopic $\underline{m} = 1$ perturbation. The instability is analyzed by dimensional analysis. The applicability of this method is discussed. A steady-state model of some experimental Penning discharges is developed. On the basis of this model, the critical magnetic field for the onset of instability as predicted by the theory agrees well with the values observed. The instability discussed here is caused by the presence of a third fluid, the neutrals, in an electron–ion plasma. The same mechanism is also applicable to the initial phase of some rotating plasmas of the homopolar type. (auth)

**33177** BREMSSTRAHLUNG IN A DENSE PLASMA. John D. Stack and Andrew M. Sessler (Univ. of California, Berkeley). Phys. Fluids, 6: 1193-5(Aug. 1963). (UCRL-10628)

It is shown that the photon-plasma interactions that result in the clothing of a bare photon must be included in the calculation of the bremsstrahlung emission rate in a dense plasma. (C.E.S.)

**33178** PICKUP COIL MEASUREMENT OF THE PLASMA MAGNETIC FIELD IN THE SCYLLA 1 THETA PINCH. F. C. Jahoda and G. A. Sawyer (Los Alamos Scientific Lab., N. Mex.). Phys. Fluids, 6: 1195-6(Aug. 1963). (LADC-5708)

A compensated pickup coil was used to detect the plasma magnetic field in the Scylla I theta pinch. The measurements, which do not perturb the plasma, verify that the external field breakthrough occurs only in the presence of a plasma probe and justifies the interpretation that the evolution of cold impurities from the probe cools the plasma and causes the breakthrough of magnetic field. (C.E.S.)

**33179** QUASI-LINEAR THEORY OF PLASMA OSCILLATIONS IN AN ELECTRIC FIELD. Peter D. Noerdlinger (Univ. of Chicago). Phys. Fluids, 6: 1196-8(Aug. 1963).

It is demonstrated that the quasi-linear truncation method for the analysis of a one-dimensional collisionless plasma of electrons and singly charged ions in a uniform external field is inadequate if the space-averaged particle distributions are assumed independent of time. It is suggested that either the equations must not be so truncated, the space-averaged distributions must be allowed to vary in time, or other concepts must be introduced if solutions free of exponentially growing waves are to be obtained. (C.E.S.)

**33180** COMMENT ON "ONE DIMENSIONAL THEORY OF RADIO-FREQUENCY CONFINEMENT." S. A. Self (Stanford Univ., Calif.). Phys. Fluids, 6: 1198-9(Aug. 1963).

It is shown that the approximations employed in a previous paper to construct a solution corresponding to a thick plasma slab isolated between conducting walls by two half waves of field are unnecessary. It is demonstrated that such solutions are possible in which the fields are of the same phase on either side of the plasma and the electric field has a nonzero minimum at its center. (C.E.S.)

**33181** THEORY OF TRANSVERSE WAVES IN VLASOV-PLASMAS. III. REFLECTION OF ELECTROMAGNETIC WAVES BY A PLASMA HALF-SPACE. B. U. Felderhof (Rijksuniversiteit, Utrecht). Physica, 29: 662-74(June 1963). (In English)

The problem of reflection of normally incident electromagnetic waves by a plasma half-space is solved. The equilibrium plasma is supposed to be spatially homogeneous and isotropic in velocity space; the particles are assumed to be reflected specularly at the plane boundary. From the multitude of stationary solutions, compatible with the latter assumption, one is selected by imposing a causality condition. The exact reflection coefficient found from this solution is compared with the results predicted by the Fresnel formula with the aid of the refractive index; the present problem leads to a natural extension of the definition of the refractive index to the range of frequencies smaller than the plasma frequency. The relation to the theory of the anomalous skin effect in metals is also discussed. (auth)

**33182** CORRELATIONS IN A NON-ISOTHERMAL PLASMA. I. Prigogine and Ph. De Gottal (Université Libre, Brussels). Physica, 29: 706-11(June 1963). (In English)

It is well known that in a plasma with sufficiently low pressure the electrons and ions are able to coexist at different temperatures. In these conditions it becomes impossible to apply the canonical distribution to calculations of electron-ion correlations and the equation of state. However, the method used permits a calculation to be carried out by evaluating corresponding "creation diagrams". In this method the correlations produced by electron-electron and ion-ion scattering have as a common asymptotic condition, as $\underline{t} \to \alpha$, the validity of the respective Maxwell distributions. (tr-auth)

**33183** THEORY OF PLASMA WAVE PROBES IN A COLLISIONLESS PLASMA. William E. Drummond (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Rev. Sci. Instr., 34: 779-81(July 1963).

The theory of the emission of longitudinal plasma waves by a pair of grids immersed in a hot plasma is developed using the Vlasov equation. The energy radiated by these grids is derived from a variation of the Landau treatment of spatially varying waves in a collisionless plasma. The principal result is that closely spaced grids have a surprisingly high efficiency for exciting the fundamental model of the plasma. (auth)

**33184** THE EQUATION OF TORSIONAL MAGNETO-HYDRODYNAMIC OSCILLATIONS OF A VISCOUS LIQUID SPHERE IN ROTATION. M. Draganu. Studia Univ. Babes-Bolyai, Ser. 1, No. 1, 261-70(1961). (In Rumanian)

The equation for the magnetohydrodynamic oscillations of a viscous liquid sphere in rotation is generalized for the case in which the viscosity of the material of which the sphere consists is considered. The case in which both the viscosity and the electric conductivity of this material are considered simultaneously is also discussed. The deduction of the generalized equations is made using methods developed by Kendall for the case of negligible viscosity and electric conductivity. (tr-auth)

**33185** THE NON-LINEAR THEORY OF A PLASMA WAVEGUIDE. A. M. Kondratenko. Ukr. Fiz. Zh., 8: 488-90(Apr. 1963). (In Ukrainian)

The propagation of an axially symmetric electromagnetic wave in a cylindrical plasma waveguide is considered on the assumption of a small nonlinearity. The nonlinear theory can take into account important effects such as the phase velocity as a function of amplitude, the appearance of higher harmonics, and the motion of the plasma boundaries. A self-consistent set of equations for the motion of the plasma was written, and the term $\epsilon = (eE_0/m\omega v_{ph})$ was taken as the small parameter. Here, $E_0$ is the amplitude of the electric wave field on the axis of the wave guide, $v_{ph}$ is the phase velocity, and $\omega$ is the frequency of the wave being propagated. An expression was derived for the electric and magnetic fields of the first harmonic in a plasma containing terms to the third degree. The nonlinear effects led to a weakening of the electric field of the first harmonic, and to an increase in the magnetic field at a given point. The phase velocity of the wave increased with increasing amplitude of the electric field. (TTT)

**33186** ON EXCITATION OF LONGITUDINAL WAVES IN A PLASMA BY RADIO WAVES. A. M. Fedorchenko (Kiev State Univ.). Ukr. Fiz. Zh., 8: 555-9(1963). (In Ukrainian)

The energy flow vector for a longitudinal electric wave in a plasma is considered. The energy flow of the longitudinal electric wave, excited by a transverse electromagnetic wave falling on the plasma-dielectric boundary, is calculated. It may be considered that only a small part of the energy of the incident electromagnetic wave is converted into the energy of the longitudinal electric wave. (auth)

**33187** INJECTION AND ACCUMULATION OF HIGH ENERGY PARTICLES IN A MAGNETIC MIRROR SYSTEM. Zheng-wu Li. Wu Li Hsueh Pao, 18: 586-93(Nov. 1962). (In Chinese)

A method to inject beams of $H_2^+$ and $H^0$ simultaneously into a magnetic mirror system is proposed. From an analysis of the flow of the neutral residual gas in the system the general equation for the rate of accumulation of fast protons is obtained. Parametric study of the condition for exponential build up of the proton density gives results different from those of Post and others. (auth)

**33188** THEORY OF STABILITY OF AN INHOMOGENEOUS RAREFIED PLASMA IN A STRONG MAGNETIC FIELD. A. A. Galeev (Novosibirsk State Univ., USSR). Zh. Eksperim. i Teor. Fiz., 44: 1920-34(June 1963). (In Russian)

The stability of an inhomogeneous plasma is considered. A method for constructing finite solutions corresponding to localized perturbations is presented. It is shown that there is a correspondence of this method to the results of application of the rough quasiclassical theory to the same problem. The shearing effect of magnetic lines of force is taken into account; this effect leads to stabilization of a "universal" instability of an inhomogeneous rarefied plasma when particle collisions can be neglected. (auth)

**33189** OSCILLATIONS OF A LOW PRESSURE INHOMOGENEOUS PLASMA. L. M. Kovrizhnykh, A. A. Rukhadze, and V. P. Silin (Lebedev Inst. of Physics, Moscow). Zh. Eksperim. i Teor. Fiz., 44: 1952-63(June 1963). (In Russian)

Geometrical-optics methods are extended to space-dispersion electrodynamics, in which the field equations are integral equations. The method is employed for analysis of the problem of magnetic confinement of a plasma. A dispersion equation for longitudinal oscillations is derived. Necessary and sufficient conditions for plasma instability can be deduced by analyzing the dispersion relation for the extreme cases of long- and short-wave oscillations. In particular, it is shown that if the electron-to-ion temperature ratio is independent of the coordinates, a weakly inhomogeneous low pressure plasma confined by a magnetic field is practically always unstable with respect to short-wave oscillations. (auth)

**33190** ANOMALOUS DIFFUSION OF A PLASMA IN THE PRESENCE OF OSCILLATIONS. V. I. Petviashvili. Zh. Eksperim. i Teor. Fiz., 44: 1993-2000(June 1963). (In Russian)

The effect of forced oscillations on diffusion of a plasma across a magnetic field is considered, in the particular case of a totally ionized plasma cylindrical column in a strong magnetic field, with a random fluctuation source located in the plane $z = 0$. (auth)

**33191** SHIFT AND BROADENING OF ENERGY LEVELS OF SINGLE-ELECTRON ATOMS AND IONS IN A HIGH TEMPERATURE PLASMA. L. E. Pargamanik and G. M. Pyatigorskii (Khar'kov State Univ.). Zh. Eksperim. i Teor. Fiz., 44: 2029-38(June 1963). (In Russian)

The shift and width of energy levels of single-electron atoms and ions in an equilibrium high-temperature plasma can be calculated by employing the spectral representation and Bethe-Saltpeter type equation for the electron-ion Green function. The calculated quantities are expressed in terms of the mass and vertex operators, which are set up by the diagram technique. The ion level shifts are proportional to the square root of the temperature and density, and, for hydrogen atoms, to the first degree of these quantities. The width is always proportional to the density. (auth)

**33192** A SINGLE-PHASE INDUCTION PLASMA ACCELERATOR. A. S. Penfold and D. L. Curtis (Litton Systems, Inc., Beverly Hills, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63012-63, 13p. (CONF-10-40)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

The theoretical characteristics and experimental operation of a pulsed plasma accelerator are described. $N_2$ gas is injected into the apex of a Cu-wound conical solenoid that carries a 1.7-Mc electric current. The gas is heated and ionized near the apex, and is accelerated as it passes through the wider portions of the cone. (T.F.H.)

**33193** THE DETERMINATION OF THE ELECTRON DENSITY PERTURBATIONS RESULTING FROM THE MIXING OF TWO DIFFERENT PLASMAS. F. V. Schultz (Univ. of Michigan, Ann Arbor). 53p. (CONF-24-5)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

The time-dependent perturbation of electron density arising from the mixing of two collisionless plasmas, characterized initially by unequal densities and equal electron temperatures, in a field-free region is investigated. It is assumed that changes in electron gas pressure, taken

to be a scalar, occur adiabatically and that, for the time interval considered, the ions are immobile. Viscosity and heat conduction are neglected. It is found that the following phenomena occur in the more-dense medium within a distance of about 1.5 Debye lengths from the interface: the electron density at the interface immediately assumes a value about midway between the two unperturbed electron densities; a rarefaction wave of increasing amplitude propagates into the more-dense medium with a velocity equal to the adiabatic acoustical velocity; after the passage of this wave, rapidly damped electron density oscillations at the two plasma frequencies occur; and after the oscillations die out, the electron density varies smoothly from a value of about one-half the difference in the unperturbed densities at the interface to the unperturbed value far from the interface. Similar phenomena are expected to occur for the less-dense medium. (auth)

**33194** ELECTRON BEAM INTERACTIONS WITH IONS IN A WARM PLASMA. R. J. Briggs and A. Bers (Massachusetts Inst. of Tech., Cambridge). 24p. (CONF-24-2)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

Conditions are determined for which the ions of a plasma might gain appreciable energy from the interaction with an electron beam. The waves along the magnetic field in a one-dimensional beam-plasma system are examined. For a cold plasma, the transverse waves exhibit a convective instability near the ion cyclotron frequency and a nonconvective instability at very low frequencies. The convective instability is greatly altered by a finite ion temperature, whereas the low frequency instability is relatively unaffected by temperature. For a weak beam, the longitudinal interaction occurs above the electron plasma frequency unless $V_0 < T_e$, where $V_0$ is the d-c beam voltage and $T_e$ is the electron temperature. A very strong interaction at the ion plasma frequency arises if $(n_b/n_p)(T_e/V_0) > 1$, where $n_b$ and $n_p$ are the beam and plasma densities. For both transverse and longitudinal interactions it is shown that the presence of damping (cyclotron or Landau) can give rise to resistive medium type instabilities. Some brief results will also be given on the interactions in finite geometries which include the electron temperature. (auth)

**33195** HIGH FREQUENCY ELECTROSTATIC INSTABILITIES IN A PLASMA. M. W. Klein and P. L. Auer (Sperry Rand Research Center, Sudbury, Mass.). 28p. (CONF-38-6)

From American Physical Society, 4th Annual Meeting, Atlantic City, N. J., Nov.-Dec., 1962.

The dispersion relation is examined for a collisionless infinite plasma in the presence of an anisotropic Maxwellian velocity distribution and a uniform external magnetic field. Unstable solutions exist below the multiples of the electron cyclotron frequency provided the temperature anisotropy is sufficiently large. The dependence of the growth rate upon harmonic number, density, angle of propagation with respect to the magnetic field, and frequency is discussed for zero as well as non-zero parallel temperatures. In the latter case, the waves are strongly damped as their frequency approaches a multiple of the gyro-frequency. (auth)

**33196** DIAGNOSTIC STUDIES OF A PINCH PLASMA ACCELERATOR. Donald P. Duclos, Leonard Aronowitz, Frederic P. Fessenden, and Peter B. Carstensen (Republic Aviation Corp., Farmingdale, N. Y.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63014A, 33p. (CONF-10-43)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Characteristics of a pinch plasma accelerator were investigated by means of measurements of the total discharge current, capacitor voltage, magnetic field distribution, and light front velocity. The current distribution and $J \times B$ force on the plasma were calculated. The results show that a current sheet resulting from the first half-cycle of current propagates along the electrodes, becoming more diffuse with time. It was observed that there are regions in the sheet where the direction of current density shows local reversals. Magnetic probes indicate that the motion of the current sheet turns from an initially radial to an axial direction and that the magnetic force on the current sheet is essentially in the direction of plasma motion. The impulse produced by $J \times B$ forces in the accelerator was computed and was found to be about 80% of the measured thrust. All of the net energy output of the capacitor bank was transferred to the accelerator in the first 2.4 μsec. (auth)

**33197** ANALYTICAL PERFORMANCE OF A PINCH PLASMA ACCELERATOR. William McIlroy (Republic Aviation Corp., Farmingdale, N. Y.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63014B, 21p. (CONF-10-44)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

The performance of an ideal pinch accelerator is analyzed on the basis of a snowplow model coupled with the external electric circuit. As a result a number of observations are made regarding the influence of the capacitance, voltage, inductance, resistance, and density distribution on the thrust/power ratio, the maximum efficiency, efficiency, and specific impulse. The qualitative trends of the theory are correlated with experiment, and indicate a direction for the design of accelerators in stipulated specific impulse, thrust, and energy ranges. (auth)

**33198** MICROWAVE-CAVITY MEASUREMENT OF THE FARADAY EFFECT IN A MAGNETOPLASMA. Frederic R. Crownfield, Jr. and Maurice T. Raiford (College of William and Mary, Williamsburg, Va.). 7p. (CONF-46-72)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

For a propagating plane-polarized wave, the Faraday effect is observed as a rotation of the plane of polarization as the wave travels parallel to the magnetic field in a medium. The analogous effect in a cylindrical $TE_{11m}$ cylindrical cavity is the coupling of the two otherwise independent orthogonal modes of the cavity. This effect was observed in a $TE_{111}$ cavity at 2000 Mc as the magnetic field was varied from 0-1000 Oe. The magneto-active medium was the positive column of a gas discharge, located coaxially in the cavity. As expected, the coupled signal exhibits a resonance when the electron-cyclotron frequency equals the signal frequency. (auth)

**33199** NONLINEAR TRANSVERSE WAVES IN PLASMAS. H. S. C. Wang and M. S. Lojko (Univ. of Colorado, Boulder). 24p. (CONF-46-67)

From American Physical Society Meeting, Washington, D. C., Apr. 1963.

The propagation of nonlinear stationary transverse waves in plasmas is investigated by first solving a relativistic Vlasov equation for the electrons under the influence of a Lorentz force due to a propagating 4-potential rigorously and without linearization. The solution, which reduces to a given equilibrium electron velocity distribution function,

is then substituted into the Maxwell equations, and a set of wave equations is obtained. While nonlinearity couples the transverse and longitudinal modes except for one special case, propagation of plane-polarized transverse waves in both cold and hot plasmas is studied in the quasi-neutrality approximation. The conditions for the existence of periodic solutions for the nonlinear transverse wave equations indicate that propagation is possible only when the wave velocity exceeds the velocity of light for plasmas free from external magnetic field. Expressions for waveform and frequency in terms of elliptical integrals are derived. Unlike the case of longitudinal waves, the nonlinear effect on transverse waves is manifested primarily in the reduction of frequency rather than distortion in waveform. Several typical examples of waveform and dispersion characteristics (frequency vs. phase velocity) are computed and plotted, ranging from cold to ultra-relativistically hot plasmas. The nonlinear effect is more pronounced at lower electron temperatures. (auth)

**33200** LONGITUDINAL AND TRANSVERSAL PLASMA WAVE INSTABILITIES IN TWO COUNTERSTREAMING PLASMAS WITHOUT EXTERNAL FIELDS. Dietrich Buenemann (Case Inst. of Tech., Cleveland). 51p. (CONF-38-7)

From American Physical Society Meeting, Atlantic City, Nov.-Dec. 1962.

Some aspects of the theory of longitudinal and transversal waves in a collisionless nonrelativistic plasma are treated. A dispersion relation for multicomponent plasmas is derived from the linearized Boltzmann-Vlasov equation using the full set of Maxwell's equations without an external field. The velocity distributions of the plasma streams are assumed to be Maxwellian. For the particular case of two counterstreaming plasmas it is shown that there exists transversal instabilities for all counterstreaming velocities whereas the well known two stream instabilities only exist for velocities greater than a critical velocity. Exact solutions for the onset of the instabilities can be given. This kind of instability may occur for any nonisotropic velocity distribution in a collisionless plasma. (auth)

**33201** INSULATOR BOUNDARY LAYERS IN MAGNETOHYDRODYNAMIC CHANNELS. Francis J. Hale (U. S. Air Force Academy, Colorado Springs, Colo.) and J. L. Kerrebrock. New York, American Inst. of Aeronautics and Astronautics, 1963, Preprint 63-201, 25p, $1.00. (CONF-97-21)

From Summer Meeting, Los Angeles, June 1963.

An investigation is made of the laminar compressible boundary layers on the insulating walls of a direct-current crossed-field plasma accelerator. Variations across the boundary layers of the electrical conductivity and Hall parameter are considered for two extremes of electrical behavior of the fluid. In the first, the electrical conductivity is assumed to take its equilibrium value at the local temperature and pressure. In the second, it is assumed that the conductivity increases as the electron temperature rises due to Joule heating. Locally similar solutions are obtained by means of a modified Stewartson transformation and by placing certain restrictions on the free-stream flow. Solutions are obtained by numerical integration. The unusual profiles, particularly for the non-equilibrium condition, clearly show the complex nature of the interactions among the gas properties, the electromagnetic fields, and the flow itself. For zero Hall parameter, a heavy electromagnetic loading and a free-stream Mach number of unity yield velocity and temperature excesses. However, as the Mach number is increased to 1.5 and then to two, the excesses are unexpectedly and progressively suppressed and large current sheets appear near the wall. A decrease in the electromagnetic loading for a Mach number of unity also suppresses the excesses and in addition thins the boundary layers. A finite and increasing Hall parameter accentuates the maxima and thins the boundary layers. For the zero Hall parameter equilibrium condition, a heavy electromagnetic loading and a Mach number of unity produce velocity and temperature excesses but of much smaller magnitude. An increase of the Mach number to two increases the magnitude of the maxima in an orderly fashion. Thicknesses are larger than those for either electrode or nonelectromagnetic boundary layers but displacement thicknesses are smaller. The average power density in the boundary layer is approximately twice that in the free-stream for non-equilibrium and a Mach number of unity because of the short circuiting effect; it decreases as the Mach number increases. Heat transfer rates, largest for non-equilibrium, are an order of magnitude larger than those in non-electromagnetic flows. The friction coefficient, also largest for non-equilibrium, is three or four times normal for a Mach number of unity. It decreases with Mach number and increases slightly with Hall parameter. (auth)

**33202** RADIATION THROUGH CYLINDRICAL PLASMA SHEATHS. J. H. Harris (Hughes Aircraft Co., Culver City, Calif.). 45p. (CONF-86-1)

From Symposium on Plasma Sheath, Bedford, Mass., Apr. 1962.

The radiation from a magnetic line source axially oriented on a conducting cylinder when the cylinder lies in a plasma sheath environment is investigated. The sheath is taken to be a series of homogeneous cylindrical layers none of which is contiguous with the cylinder. Characteristics of the radiation field are discussed and some radiation patterns are presented. The patterns are found to have large narrow amplitude fluctuations that can be attributed to leaky waves. (auth)

**33203** THE PLASMA PINCH AS A GAS ACCELERATOR. Robert G. Jahn and Woldemar von Jaskowsky (Princeton Univ., N. J.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63013, 24p. (CONF-10-42)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

A large radius pinch discharge produces a series of cylindrically symmetric, inwardly propagating current sheets and associated magnetic fields in a form convenient for detailed study of the $j \times B$ interactions basic to all schemes of electromagnetic gas acceleration. These are examined by streak and Kerr-cell photography, magnetic probes, spectroscopy, and terminal measurements of current and voltage fluctuations, to determine the detailed distribution of the currents and fields within the discharge as functions of radius and time. An inverse-pinch discharge provides a convenient switch for the rapid application of the high voltage pulse to the electrodes. The initiation of the main discharge in a uniform peripheral ring is found to be primarily an inductive effect, conditioned somewhat by the presence of the adjacent insulator surface. Spectrograms of discharges in argon, nitrogen, and helium show singly and doubly ionized species indicating that particles of energy in excess of 25 ev are participating in the breakdown. A precursor front is observed to propagate ahead of the first current sheet, and is tentatively identified as a gasdynamic shock. (auth)

**33204** CONTINUOUS PLASMA ACCELERATION AT ELECTRON CYCLOTRON RESONANCE. H. W. Hendel and T. Todd Reboul (Radio Corp. of America, Princeton, N. J.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63001-63, 10p. (CONF-10-48)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Experimental and analytical results are presented covering a continuous method of accelerating neutral plasmas. By raising the electron energy selectively in electron cyclotron resonance and transferring this energy to the ions by space charge interaction, plasma beams were produced at specific impulses and thrusts of interest for space propulsion. In the well collimated plasma beam produced during the preliminary experiments demonstrating the effect, a thrust of 10 dynes/cm$^2$ was measured by means of a mechanical vane. Mercury ion energies from 50 to 135 ev at densities of $5 \times 10^{10}$ per cm$^3$ were measured by means of a retarding potential energy analyzer. Within the experimental limitations good agreement between theory and experiment was obtained. A substantial increase in thrust density and an increase in specific impulse appears feasible by optimization of the experimental parameters. (auth)

**33205** THE HALL CURRENT PLASMA ACCELERATOR. Gordon L. Cann, Richard W. Ziemer, and Gary L. Marlotte (Electro-Optical Systems, Inc., Pasadena, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63011, 35p. (CONF-10-41)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

A theoretical and experimental investigation was made of the operation of a relatively new type of plasma accelerator—the Hall Current Accelerator. This device employs the radial component of a fringing magnetic field, a Hall induced current, and an axial discharge to obtain the electromagnetic acceleration of a neutral plasma. A theoretical determination is made of the net accelerating force per unit volume exerted upon the plasma. On the basis of a three particle gas kinetic theory, exact equations for the three components of the accelerating force are derived. The axial force component, which is predominant, is shown to be equivalent to the electrostatic acceleration of the ions, the electrons being trapped by the applied magnetic field. It can also be shown to be equivalent to the Lorentz force resulting from the cross product of the Hall induced azimuthal current and the applied radial magnetic field, whence the name Hall current accelerator. The mechanisms by which energy is transferred from the electromagnetic field to the gas is also studied. It is found that the energy is transmitted to the gas through the acceleration of the ions only and that the electrons do not receive any energy directly from the field. Having derived the relations for the electromagnetic force and energy transfer rate per unit volume, a gas dynamic analysis is made. Regimes of operation for a constant area accelerator are outlined, showing the importance of the critical parameters of Mach numbers and ion slip ratio. Integral solutions are obtained showing that arbitrarily high velocity ratios across the accelerator are obtainable. Expressions for the thrust efficiency are obtained and evaluated. The performance capability of an ideal Hall accelerator is compared with that of an ideal crossed field accelerator and it is shown that the Hall accelerator has many potential advantages over the $J \times B$ device. Knowledge of the plasma properties is necessary for the theoretical evaluation, particularly $\omega_e \tau_e$ and $\omega_i \tau_i$. Since adequate data were not available, the values of these Hall parameters were computed for argon and helium, the expellants of primary interest. Involved in these computations are the determination of the various collision cross sections for momentum transfer that are also presented. Hall current accelerators of both cylindrical and annular geometries were built and operated. An arc jet is used to generate the plasma to which momentum is added by a 2.5 inch diameter Hall device. A combination thrust target and calorimeter is used to measure the total enthalpy and momentum in the plasma stream. Tests with the cylindrical geometry showed Hall current acceleration to occur. However, since the radial magnetic field vanishes on the axis of the channel, the current would concentrate along the center line and not be effectively accelerated. An annular geometry accelerator was built with a radius ratio of 2.4 and operated with both argon and helium plasmas. The Hall acceleration was measured under varying conditions of plasma density, magnetic field strength, and accelerator current. Velocity ratios of up to 2.78 were obtained. A correlation of the experimental results with the theory are made and excellent agreement is found. The potentialities of the Hall accelerator are presented which, with further development, appear to be most promising. (auth)

**33206** ACCELERATION OF PLASMA BY DISPLACEMENT CURRENTS RESULTING FROM IONIZATION. R. H. Lovberg (General Atomic Div., General Dynamics Corp., San Diego, Calif.). 16p. (CONF-75-2; GA-4363)

From Sixth International Conference on the Ionization Phenomena in Gases, Orsay, France, July 1963.

A short parallel-plate plasma accelerator produces current sheets that are, for the time of a transit of several centimeters of the device, quite flat, and thereby nearly one-dimensional in character. A detailed measurement of the electric and magnetic field structure of this system leads to the conclusion that in the first magnetic interface produced during an oscillating discharge, the current is carried almost entirely by ions that, subsequent to their production by the advancing sheet, step one gyro-radius away from their accompanying electrons, thus producing a displacement current. (auth)

**33207** PERFORMANCE OF COAXIAL PLASMA GUN WITH VARIOUS PROPELLANTS. Charles J. Michels and Peter Ramins (Lewis Research Center, Cleveland). 18p. (CONF-93-2)

From International Coaxial Plasma Gun Symposium, Cleveland, Sept. 1962.

An experimental study of a single-shot coaxial plasma gun is described. A parametric survey of the gun over the operating range is given for each of three propellants, argon, nitrogen, and hydrogen. An optimum delay time (with respect to exhaust puff energy) is described for each propellant between gas injection and bank-voltage application. Bank voltage and mass per shot were varied using the optimum delay time. Gun efficiency, system efficiency, and magnetic front velocity in the gun were determined. (auth)

**33208** ELECTRON-ION REACTION RATE THEORY: DETERMINATION OF THE PROPERTIES OF NON-EQUILIBRIUM MONATOMIC PLASMAS IN MHD GENERATORS AND ACCELERATORS AND IN SHOCK TUBES. Stanley Byron, Paul I. Bortz, and Gary R. Russell (Aeronutronic Div., Ford Motor Co., Newport Beach, Calif.). 10p. (CONF-24-15)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

The theoretical analysis required to determine the electron density, electron temperature, excited state populations, and radiation emission in monatomic plasmas is

presented. Calculations of collision cross sections using the semi-classical method of Gryzinski for some of the noble gases and alkali metal vapors are given. Available information on radiative transition probabilities is reviewed. The influence of self-absorption of radiation for the density and temperature range found in MHD devices and in shock tube experiments is examined. Combining the collisional and radiative transition probabilities, a general electron-ion reaction rate theory is obtained. The range of physical parameters over which various non-equilibrium effects are significant is examined. In fluid dynamic problems, this reaction rate theory is combined with a two-fluid, two-temperature model of the gas, treating the electrons as one specie and the ions and neutrals as the other. This theory is applied to the problem of determining the state of the gas in the non-equilibrium MHD generator, the crossed-field accelerator, and the shock tube. (auth)

**33209** ELECTRODE PHENOMENA, TENSOR CONDUCTIVITY AND ELECTRODE HEATING IN SEEDED ARGON. Z. Croitoru and A. de Montardy (Electricite de France, Paris). 7p. (CONF-24-14)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

Contact potential drops along the electrodes often prevent measurements of ionized gas conductivity. In order to avoid such potential drops, a measurement cell using double probe technique was realized. By adding a third probe, it is also possible to measure the conductivity tensor components. Formulas commonly used are shown to be incorrect. In order to evaluate non-equilibrium conductivity, the excitation temperature of the seed is to be considered, rather than electron temperature, especially in small scale experiments, where charged particle losses by ambipolar diffusion are to be expected. (auth)

**33210** THREE-FLUID NONEQUILIBRIUM PLASMA ACCELERATORS. PART II. P. D. Lenn, J. R. Bodoia, D. L. Ward, G. L. Hamilton, and S. T. Demetriades (Northrop Space Labs., Hawthorne, Calif.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63047, 25p. (CONF-10-55)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

A three-fluid theory of nonequilibrium plasma flow, with emphasis on crossed-field accelerators, is extended. A theory of the heat transfer to the electrodes of a crossed-field accelerator is developed that includes the effects of the three-fluid behavior of the plasma and of the applied electromagnetic fields. The analysis indicates that the electrical power dissipation in the electrode drop region is the major source of heat transfer to "cold" electrodes. Experimental heat transfer values are determined from calorimetric measurements on water-cooled electrodes. Data obtained over a range of magnetic field strengths, accelerator power levels, and channel pressures are shown to fit a correlation of the form developed analytically. Indications are discussed that large ion currents exist in the cathode fall region and that low effective values of the cathode work function are not necessary to explain the current densities obtained with "cold" electrodes. Measurements are reported for the performance of a continuous crossed-field accelerator as a function of magnetic field strength, accelerator power, applied current, and electrode position. A complete analytic description of an accelerator is formulated using assumed averages of the spatially distributed variables and is shown to yield results in agreement with the experiments. Experimental verification of the theoretical results indicates that the phenomenological description of accelerators given includes all of the major effects. (auth)

**33211** RADIO FREQUENCY HEATING OF A DENSE, MOVING PLASMA. A. Mironer and F. Hushfar (Allied Research Associates, Inc., Concord, Mass.). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63045-63, 13p. (CONF-10-53)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Theoretical and preliminary experimental work in r-f energy addition to a dense, moving plasma stream is described. It is shown that for a dense plasma near thermal equilibrium, the product of the skin depth (measure of the depth of penetration into the plasma of the induced currents) and the square root of the frequency are a function of the thermodynamic state of the plasma. It is further shown that the distribution of r-f-generated power in the plasma and the efficiency of energy coupling may be controlled by proper selection of frequency and discharge volume diameter for a plasma possessing certain desired properties. The results of a one-dimensional flow analysis for an ionized, monatomic gas undergoing energy addition in a constant-area duct are described. A curve showing the product of the skin depth and the square root of the frequency as a function of the total gas enthalpy for parameters of mass flux is presented. Curves showing the power generation distribution are also presented. These curves help estimate the proper frequency and discharge volume diameter for efficiently heating a plasma by high-frequency energy coupling. Some r-f coil configurations and some qualitative results obtained with them are described. A water-jacketed-coil design is described, which shows promise of allowing the enthalpy level of the r-f plasma to be substantially increased. The importance of proper matching of the impedance of the coil configuration to the operating parameters of the power supply for efficient energy coupling is discussed. Various methods of discharge initiation and stabilization are described. (auth)

**33212** STUDIES OF FLUID MECHANICS USING A LARGE, COMBUSTION DRIVEN MHD GENERATOR. J. F. Louis, J. Lothrop, and T. R. Brogan (Avco Corp., Everett, Mass.). 54p. (CONF-24-13)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

A presentation and analysis are given of the results of a study of the fluid mechanics of MHD generators carried out at Avco-Everett Research Laboratory. A large, combustion-driven MHD generator (the Mark II) was built with the objective of gaining the detailed knowledge required for the prediction of performance of MHD generators. Outputs as high as 1480 kilowatts have been achieved with the generator. The design considerations which led to an experiment with a large interaction between flow and magnetic field along with comparatively small viscous losses and significant Hall coefficient are described. These considerations determine the diameter and length of the channel and the strength of the magnetic field. Experimental studies of the electrical properties are described along with experiments performed to determine the Maxwell-averaged collision cross section and Hall coefficient of these gases. The influence of surface temperature, material, and geometry of the electrodes on performance is described. The performance of the Mark II as influenced by various parameters is described. Among the parameters

which have been varied are included mass flow, magnetic field, seed concentration, generator exhaust pressure (through the use of a diffuser), and the geometry of the generator channel. As the study progressed it gradually became possible to explain the observed results on the basis of a simple theory, largely one-dimensional. Although correlation of observed results with those predicted with the above analysis is still proceeding for more recent experimental work, comparison of experimental data with predicted performance in detail yielded good agreement, indicating the feasibility of predicting MHD generator performance. (auth)

**33213** PLASMA ANALYSIS WITH THE BENDIX TIME-OF-FLIGHT MASS SPECTROMETER. G. J. O'Halloran and R. A. Fluegge (Bendix Corp., Detroit). 22p. (CONF-74-9)

From Conference on Mass Spectrometry and Allied Topics, San Francisco, May 1963.

The results of a recent experimental program that demonstrated the feasibility of using a time-of-flight mass spectrometer for the direct sampling of a high energy density plasma are discussed. Data that confirm the capability of this instrumentation to provide qualitative information about the plasma phenomenology are presented. Plans for experimentally evaluating the quantitative capabilities of the equipment are summarized. The mass spectra obtained using an argon plasma operating in a room-air atmosphere showed the presence of $^{40}A$, $^{28}N_2$, $^{32}O_2$, and $^{18}H_2O$; and $^{40}A^+$, $^{28}N_2^+$, $^{18}H_2O^+$, $^{16}O^+$, $^{14}N^+$, $^{44}CO_2^+$, $^{63}Cu^+$, $^{65}Cu^+$, $^{32}O_2^+$, and $^{17}OH^+$ for the respective neutral and ionized species of the plasma. The mass spectra indicate that the relative ion concentration is about $2.5 \times 10^{-6}$ and that the ion density is about $5.2 \times 10^{12}$ ions $cm^{-3}$. The variation of $^{40}A^+$, $^{28}N_2^+$, and $^{32}O_2^+$ ions as a function of longitudinal position in the plasma stream is presented and the variation of $^{40}A^+$ and $^{28}N_2^+$ ions with respect to plasma generator power is shown. (auth)

**33214** ELECTRON TEMPERATURE IN A $\theta$ PINCH DETERMINED FROM IMPURITY LINE RADIATION. R. W. Kilb and L. M. Goldman (General Electric Research Lab., Schenectady, N. Y.). 11p. (CONF-78-1)

From American Physical Society Meeting, Buffalo, June 1963.

The time variation of the impurity line radiation was analyzed to determine the electron temperature in a $\theta$ pinch. The appearance time, peak intensity time, and disappearance time of an impurity line depend on the time history of the electron density and temperature. If the electron density is known from other measurements, the time variation of the electron temperature can be determined. Data for a deuterium plasma are presented. (C.E.S.)

**33215** GYRO-INTERACTION OF MICROWAVES IN MAGNETO PLASMAS IN ATMOSPHERIC GASES. K. V. Narasinga Rao and L. Goldstein (Univ. of Illinois, Urbana). 12p. (CONF-70-2)

From National Symposium of the Professional Technical Group on Microwave Theory and Techniques, Santa Monica, Calif., May 1963.

Electron cyclotron resonance absorption of microwave energy by the electron gas in decaying magneto plasmas of oxygen and nitrogen gases is investigated. The technique of interaction of microwaves of different frequencies is utilized to measure the enhancement in electronic energy caused by resonance absorption. The results of these experiments show that the inelastic collisions of low energy electrons introduce a barrier for rapid heating of the electron gas. The implication of these results to the control of the ionospheric plasma parameters by radio frequency EM waves is discussed. (auth)

**33216** CONDUCTIVITY OF CESIUM-SEEDED ATMOSPHERIC PRESSURE PLASMAS NEAR THERMAL EQUILIBRIUM. L. P. Harris (General Electric Research Lab., Schenectady, N. Y.). 24p. (CONF-24-7; 63-RL-3278G)

From Engineering Aspects of Magnetohydrodynamics Symposium, Berkeley, Calif., Apr. 1963.

Measurements were made of the electric conductivities of gaseous mixtures formed by the addition of small fractions of cesium vapor to nitrogen, helium, neon, or argon. The mixtures studied were maintained near thermal equilibrium at temperatures in the 1500 to 2000°K range and a total pressure of 1 atm. The cesium vapor pressures ranged over two decades, from 0.1 to 10 torr. The apparatus consists, in essence, of two heated zones connected by a slow flow. The first zone is a low-temperature (200 to 400°C) oven where the body-gas flow picks up the cesium vapor. The second zone is a small electrically heated furnace (1250 to 1850°C) containing a diode test section. The principal measurements taken were the seeding temperature, furnace temperature, and voltages and currents in the test section. The results exhibit variations with temperature, seeding pressure, and gas species that correlate reasonably well with simple theory and values for electron collision frequencies and cross sections taken from the literature. (auth)

**33217** A GATED RADIOMETER FOR PLASMA AFTERGLOW STUDY. W. C. Taft, K. C. Stotz, and E. H. Holt (Rensselaer Polytechnic Inst., Troy, N. Y.). 27p. (CONF-46-42)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

In order to monitor the electron temperature during plasma afterglow experiments, a gated microwave radiometer was developed. The radiometer differs from the usual Dicke type of radiometer in the input switching scheme and in the fact that a good time resolution is required. The radiometer has a time resolution of one microsecond and a temperature sensitivity of about ten degrees when measuring temperatures near room temperature. The response time when used with a repetitive afterglow is 20 seconds. Measurements of electron temperature in a decaying nitrogen plasma were made during the initial 300 microseconds of the afterglow. (auth)

**33218** TRANSMISSION OF ELECTROMAGNETIC WAVES THROUGH PLASMA SLABS. P. M. Platzman and S. J. Buchsbaum (Bell Telephone Labs., Murray Hill, N. J.). 36p. (CONF-46-35)

From American Physical Society Spring Meeting, Washington, D. C., Apr. 1963.

The steady-state properties of circularly polarized, electromagnetic waves propagating along a static magnetic field in plasmas characterized by a nonlocal conductivity are considered. The coupled Maxwell-Boltzmann equations are solved in the presence of short range collisions for the wave that exhibits a resonance at frequencies near the electron cyclotron frequency. Expressions for the reflection and transmission of these waves for finite plasma slabs are obtained when the magnetic field is normal to the face of the slab. The expressions are explicitly evaluated and discussed for a wide range of physical parameters. The effect of temperature in the case of gaseous plasmas, and of degeneracy in the case of metals, on the

transmission characteristics of the incident wave produce two effects: At frequencies below the cyclotron frequencies the position, width, and amplitude of the Fabry-Perot transmission resonances that occur in plasmas characterized by a local conductivity are altered; at frequencies above the cyclotron frequencies anomalously large transmission occurs as a result of a field splash type of resonance. (auth)

**33219** MHD CONVERSION IN INHOMOGENEOUS FLOW. P. Ricateau and P. Zettwoog (Commissariat a l'Energie Atomique, Saclay, France). 24p. (CONF-24-16). (IFP-8463; CEA-PA-IGn-RT-185)

From Symposium, Engineering Aspects of Magnetohydrodynamics, Berkeley, Calif., Apr. 1963.

The use of temperature-modulated gases should make possible energy conversion at a mean temperature markedly lower than in classical devices. The mechanism of conversion is studied in a simplified model consisting of alternate homogeneous region of different temperatures $T_1$ and $T_2$. The interest of keeping constant the temperature of the hot region is shown, the colder regions expanding in a quasi-isentropic manner. Under the above assumptions, the expressions of efficiency and specific power are given. In a modulated structure, the Hall effect has less influence than in a homogeneous flow. However, some causes of perturbation are acting to destroy the inhomogeneous structure by molecular or turbulent diffusion. The most important cause seems to be the Rayleigh-Taylor instability. The time of development of this instability is expressed under different conditions. Finally, values of efficiency and specific power are calculated for various conversion plants with this type of modulated flow. (auth)

**33220** DEVICE FOR GENERATING A HIGH-TEMPERATURE PLASMA OF HIGH DENSITY. G. Weiss (to Pintsch Bamag AG). German Patent 1,149,465. May 30, 1963. Filed Jan. 23, 1958.

A pinch device is described for generating a high-temperature plasma of high density. It is very difficult to maintain a stabilized pinch discharge over a long period of time because the magnetic lines of force accompanying the discharge current cause instabilities. In order to overcome this difficulty, the current path is surrounded by a superconductor. As magnetic fields are excluded from the interior of metals which are in the superconducting state, the superconductor acts like a wall for the magnetic field which confines the reaction zone. (Gmelin Inst.)

**33221** MAGNETIC END CLOSURES FOR PLASMA CONFINING AND HEATING DEVICES. Richard F. Post (to U. S. Atomic Energy Commission). U. S. Patent 3,101,310. Aug. 20, 1963.

More effective magnetic closure field regions for various open-ended containment magnetic fields used in fusion reactor devices are provided by several spaced, coaxially-aligned solenoids utilized to produce a series of nodal field regions of uniform or, preferably, of incrementally increasing intensity separated by lower intensity regions outwardly from the ends of said containment zone. Plasma sources may also be provided to inject plasma into said lower intensity areas to increase plasma density therein. Plasma may then be transported, by plasma diffusion mechanisms provided by the nodal fields, into the containment field. With correlated plasma densities and nodal field spacings approximating the mean free particle collision path length in the zones between the nodal fields, optimum closure effectiveness is obtained. (AEC)

## Shielding

**33222** (ORNL-3473) HIGH DENSITY SLAG CONCRETE. T. E. Northup (Oak Ridge National Lab., Tenn.). Aug. 9, 1963. Contract W-7405-eng-26. 78p.

Thesis submitted to Univ. of Tennessee.

Test results are presented that show that a strong concrete weighing approximately 185 lb/ft$^3$ can be made using water, waste lead slag, and Ciment Fondu. Feasibility, materials, mortar tests, concrete tests, and Ciment Fondu concretes are discussed. A 24-in.-thick concrete shield wall would have to be increased in thickness by 5 in. if slag concrete is used in place of barytes or magnetite concrete. On a pound-for-pound basis, the waste lead slag concrete materials were 30% cheaper than barytes and magnetite concrete materials. (M.C.G.)

**33223** (UCRL-Trans-972) STOPPING POWER OF ATOMS HAVING MANY ELECTRONS. F. Bloch. Translated by J. Patrick (Univ. of California Lawrence Radiation Lab., Berkeley) from Z. Physik, 81: 363-76(1933). 18p.

The stopping power of very complicated atoms is calculated by the method of Thomas-Fermi. A simple relation with the atomic number is derived, and comparison with experimental values and other calculated values shows its validity. (auth)

**33224** GAMMA RAY REFLECTION FACTORS FROM CONCRETE. Arthur B. Chilton (Univ. of Illinois, Urbana). 19p. (CONF-39-9).

From American Nuclear Society Annual Meeting, Salt Lake City, June 1963.

By means of the differential dose albedo formula, the field from a point source of gamma radiation near a concrete-air interface is mapped for those conditions in which the distances involved are larger than a mean-free-path in concrete but substantially smaller than a mean-free-path in air. Once the parameters for the albedo formula are selected, the computation of reflection factors can be carried out to any desired degree of accuracy. Computational errors are kept to substantially less than 5% of the resulting output values. (C.E.S.)

**33225** A MATHEMATICAL APPROACH TO ECONOMY OF EXPERIMENT IN DETERMINATIONS OF THE DIFFERENTIAL DOSE ALBEDO OF GAMMA RAYS. N. F. Shoemaker and C. M. Huddleston (Naval Civil Engineering Lab., Port Hueneme, Calif.). 19p. (CONF-39-5)

From American Nuclear Society Annual Meeting, Salt Lake City, June 1963.

Treatments of the differential dose albedo of gamma rays on concrete have supposed that the albedo value is a function of: the energy of the incident gamma radiation, the polar angle of incidence, the polar angle of reflection (or scatter), and the azimuthal angle of reflection. It is demonstrated that, if certain reasonable assumptions are made regarding the mechanism of reflection, it is not necessary to investigate variations in albedo with azimuthal angle of reflection. Once differential dose albedo has been determined for a complete set of incident and reflected polar angles with zero azimuth, albedo at any azimuth can be derived by a suitable transformation. (auth)

## Theoretical Physics

**33226** (NYO-10429) THE DEVELOPMENT AND USE OF METHODS OF LR TYPE. Beresford Parlett (New York Univ., New York. Atomic Energy Commission Computing

and Applied Mathematics Center). June 1, 1963. Contract AT(30-1)-1480. 47p.

The development and properties of computational methods for finding the eigenvalues of a general matrix are discussed. Methods in which a sequence of similar matrices with a triangular limit is generated from the given matrix are considered. The treatment begins with classical function theory and passes through a study of Aitken's scheme to an examination of the QD, LR, and QR algorithms and transformations. Methods for finding the eigenvalues of real symmetric tridiagonal matrices are also considered. (D.C.W.)

**33227** (NYO-10431) A METHOD OF CALCULATING GROUND-STATE PROPERTIES OF MANY PARTICLE SYSTEMS USING REDUCED DENSITY MATRICES. Claude Garrod and Jerome K. Percus (New York Univ., New York. Atomic Energy Commission Computing and Applied Mathematics Center). July 15, 1963. Contract [AT(30-1)-1480]. 46p.

The following problem is considered: Given an operator, $\Gamma(x_1,x_2|y_1,y_2)$, under what conditions can one be sure that there exists at least one quantum mechanical ensemble of N identical particles for which $\Gamma$ represents the two-particle reduced density matrix. Fairly stringent necessary conditions are presented. In the classical limit these conditions are shown to be sufficient. Some simple applications are given. (auth)

**33228** QUANTUM MECHANICAL HAMILTONIAN IN GROUP OPERATOR FORM AND THE MOLECULAR HAMILTONIAN. B. T. Darling (Laval Univ., Quebec). J. Mol. Spectry., 11: 67-78(July 1963).

A method for separating the rotational from the internal motion in a many-particle quantum mechanical system is discussed. A generalization of the transformation of the Laplacian-type kinetic energy operator of the Schrödinger equation to curvilinear coordinates is used. The kinetic energy operator of the many-particle Schrödinger equation is expressed in terms of group operators, and the results are used to derive the molecular Hamiltonian for the rotation-vibration of molecules. (auth)

**33229** INTEGRATION OF THE DISPERSION EQUATIONS—RELATION BETWEEN ABSORPTION AND DISPERSION. J. Vincent-Geisse (Laboratoire de Recherches Physiques, Sorbonne, France). J. Phys., 24: 259-64(Apr. 1963). (In French)

Classical dispersion formulas furnish, for all wavelengths, a relation between absorption and dispersion. The integration of these equations is performed in a particular case and gives an approximate relation between the dispersion in the neighborhood of a band and the integrated intensity of this same band. This result is extended to the general case by means of an exact calculation of the integrated absorption coefficient. The result thus obtained is then compared with the one that may be deduced from an integral relation. (auth)

**33230** VARIATION PRINCIPLES FOR AN ARBITRARY OPERATOR. II. OFF-DIAGONAL ELEMENTS AND SCATTERING STATES. L. M. Delves (Univ. of New South Wales, Kensington, Australia). Nucl. Phys., 45: 313-20(July 1963). (In English)

In a previous paper a variation principle was given for the diagonal matrix elements $\langle\alpha|W|\alpha\rangle$ of an arbitrary Hermitian operator W. The method is extended to give variation principles for the off-diagonal elements $\langle\alpha|W|\beta\rangle$, separate principles being given for the real and imaginary parts of the matrix element. The results apply directly to bound state solutions of the Schrödinger equation; the extension to scattering states representing arbitrarily involved collisions is also given, and variation principles are derived for matrix elements between two scattering states and between scattering and bound states. (auth)

**33231** THE EVOLUTION TO QUANTUM STATISTICAL EQUILIBRIUM FOR A SIMPLE MODEL. II. A NUMERICAL SOLUTION. E. Verboven and L. Buyst (Studiecentrum voor Kernenergie, Mol, Belg.). Physica, 29: 653-61(June 1963). (In English)

A simple model, introduced by L. Van Hove and E. Verboven, to investigate the evolution to quantum statistical equilibrium is solved numerically for the diagonal part of the transition probability density. For $\lambda = 0.1$ the weak-coupling approximation and the numerical solutions agree very well. For $\lambda = 10$ the strong-coupling and numerical solution practically coincide. For $\lambda = 1$ the numerical solution differs considerably from the weak coupling and strong-coupling solutions, showing the existence of an intermediate coupling region. (auth)

**33232** ON THE EQUIVALENCE BETWEEN TWO GENERALIZED MASTER EQUATIONS. P. Resibois (Université Libre, Brussels). Physica, 29: 721-41(June 1963). (In English)

The relationship between the master equation derived, respectively, by L. Van Hove and by I. Prigogine and the author is analyzed. It is shown that the difference between the two approaches essentially lies in a different definition of the irreducible contributions defining the transition probabilities. In the latter formalism, the criterion used is a dynamical one, corresponding to an analysis of the time ordering of the interactions bringing the system toward equilibrium. On the contrary, the former approach defines irreducibility by inspection of the structure of the matrix elements in the product space $\langle n|\otimes|n\rangle$, irrespective of any dynamical consideration; this has as a consequence that it is not possible to obtain a master-equation for the density matrix itself in contrast with the dynamical formalism. (auth)

**33233** MALFORMED INTERACTIONS IN UNITARITY METRIC THEORY. Shoichi Hori (Kanazawa Univ., [Japan]). Progr. Theoret. Phys. (Kyoto), 29: 612(Apr. 1963). (In Esperanto)

**33234** ON THE PROBLEM OF AMBIGUITY IN THE PHASE SHIFT ANALYSIS OF SCATTERING PROCESSES. Nien-ning Huang. Wu Li Hsueh Pao, 19: 306-19(May 1963). (In Chinese)

Starting from the conditions that should be satisfied by the existence of different choice in the phase shift analysis, the general ambiguity in the analysis of elastic scattering of particles with arbitrary spins is discussed. The transformation matrices among the different sets of phase shift are given. The real parameters involved are determined by the system of second-order algebraic equations. The problem of ambiguity in the phase shift analysis therefore is reduced to the problem of finding the real roots of those equations. The number of different sets of real roots is twice that of different phase shift choice. Therefore, the kinematical ambiguity in the phase shift analysis in general is solved. When the channel spin is $\frac{1}{2}$, it is shown that only two sets of phase shift exist; when the channel spin is 1, only two sets of phase shift are given also. Therefore it is shown that the Minami's ambiguity is the whole ambiguity in these cases. When the channel spin is $\frac{3}{2}$, it is found that there are four different sets of phase shift. Therefore, there are two new transformation matrices in this case. In

general, the ambiguity in the phase shift analysis corresponds to the motion of spin that conserves the components of spin-tensors in the direction of momentum, and the parameters that characterize those general spin motion take the fixed values. It is shown that the systems of algebraic equations satisfied by the real parameters in the transformation matrices in the integral-spin cases are quite different from those in the half-integral-spin cases. Therefore, the numbers of real roots in those two cases are also different, so that the numbers of different phase shifts sets are quite different. From the properties of those algebraic equations it is suggested that the ambiguity in the case of integer spin is much smaller than that in the case of half-integer spin. (auth)

# REACTOR TECHNOLOGY

## General and Miscellaneous

*Refer also to abstracts 31794, 31799, 32165, 32524, 32525, 32549, and 32698.*

**33235** (AAEC/TM-198) A PRELIMINARY REVIEW OF THE DESIGN AND FEASIBILITY OF PRESTRESSED CONCRETE PRESSURE VESSELS FOR NUCLEAR REACTORS. N. D. Holt (Australia. Atomic Energy Commission Research Establishment, Lucas Heights, New South Wales). June 1963. 37p.

The design of prestressed concrete pressure vessels is discussed, and some approximate design formulas are developed. The design and performance of vessels reported in the literature are reviewed, and an approximate comparison is made of steel and concrete pressure vessels for a particular case. Concrete vessels are attractive for moderate temperatures and pressures because of the large size of vessel which can be built and the nonexplosive mode of failure. However, it is unlikely that large cost savings will be made by using prestressed concrete instead of steel for the pressure vessels. (auth)

**33236** (ACNP-63022) SHAPED BURNABLE POISON DEVELOPMENT PROGRAM UNDER THE EURATOM PROGRAM. Quarterly Progress Report, March 1, 1963–June 30, 1963. (Allis-Chalmers Mfg. Co. Atomic Energy Div., Milwaukee). July 10, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(11-1)-1229. 57p. (EURAEC-759)

Poison demand curves were computed for a boiling water reactor with $H_2O$ to $UO_2$ ratios of 2.1 and 3.0, a uranium-235 enrichment of 3.3 wt %, and fuel depletions in the range of 10,000 to 25,000 Mwd/t. These curves indicate poison lumps in the form of cylinders to be desirable. For these same reactors, the excess reactivity was computed for the cold clean, hot clean non-voided, and hot full-power equilibrium conditions. The excess reactivity was computed with and without a black burnable poison sized for the full power equilibrium condition. The moderator temperature defect and reactor operating power defect are increased substantially if computed including explicitly the effect of a black poison. Model development was completed for depleting isolated cylinders. Initial self-shielding factors were computed as a function of cylinder radius for ten neutron temperatures. Depletion calculations were performed for four values of cylinder diameter and neutron temperature. Gadolinia cylinders in alumina rods were formed and sintered at temperatures up to 2850°F. A reaction between $Al_2O_3$ and $Gd_2O_3$ begins at 2650°F. Investigations were begun of reaction between $UO_2$ and $Gd_2O_3$. Development was completed on methods to make $Gd_2O_3$ cylinders and wafers for the poison samples required by the physics studies. A method of uniformly dispersing cylinders of $Gd_2O_3$ in $Al_2O_3$ or $UO_2$ was developed, and initial tests indicate that the method is successful. (auth)

**33237** (AE-110) SEMIANALYTICAL AND SEMI-NUMERICAL CALCULATIONS OF OPTIMUM MATERIAL DISTRIBUTIONS. C. I. Gunnar Andersson (Aktiebolaget Atomenergi, Stockholm). June 1963. 26p.

Perturbation theory applied to the multigroup diffusion equations gives a general condition for optimum distribution of reactor materials. A certain function of the material densities and the fluxes, called the W (height) function, must thus be constant where the variable material density is larger than zero if changes in this density affect only the group constants where the changes occur. The weight function is, however, generally a complicated function and complete solutions were therefore previously presented only for the special case when constant weight function implies constant thermal flux. It is demonstrated that the condition of constant weight function can be used together with methods for numerical solution of the multigroup diffusion equations to obtain optimum material distributions also when the thermal flux varies over the core. Solution of the minimum fuel mass problem for two reflected reactors thus shows that an effective reflector such as $D_2O$ gives a peak in the optimum fuel distribution at the core-reflector interface, while an ineffective reflector such as a breeder blanket or a steel tank wall "pushes" the fuel away from the strongly absorbing zone. The effective reflector case was compared with analytically obtained solutions corresponding to flat power density, flat thermal flux, and flat fuel density. (auth)

**33238** (CVNA-146(Vols.I & II)) NDC — A FORTRAN PROGRAM FOR UNIT CELL NUCLEAR DESIGN CALCULATIONS FOR ROD-CLUSTERED PRESSURE TUBE LATTICES. VOLUME I. PROGRAM FORMULATION AND APPLICATION. VOLUME II. PROGRAM COMPOSITION AND LISTING. Raymond G. Saint-Paul and Surendra A. Raje (Westinghouse Electric Corp. Atomic Power Div., Pittsburgh). For Carolinas-Virginia Nuclear Power Associates, Inc., Columbia, S. C.). Contract AT(30-1)-2289. 346p.

The NDC (Nuclear Design Calculations) Program was developed in FORTRAN for use on the IBM-704/709/7090 to compute the reactivity and burnup properties of pressure-tube lattices with clustered fuel rods by applying the unit cell method. The required input consists of the fuel assembly and the tube lattice geometry, the material distributions, and some physical data. The unit cell analysis is applied to a piecewise homogeneous, cylindrical, equivalent model of the actual reactor structure. The Amouyal-Benoist method is used to obtain the thermal utilization. The Dancoff correction and the Doppler factor is applied in evaluating the resonance integral for the fissionable materials. The Spinrad approach is used to compute the fast fission factor. The resonance fissions feedback is taken into account in the neutron cycle. Only the U–Pu series is considered in the cell-homogenized depletion calculations. The program output includes the equivalent cylindrical geometry, the various cross sections, the criticality factors, the initial conversion ratio, and the burnup results. Provision for temperature and void coefficients evaluation is made. A 32 k machine is required. Typical problem running times on the IBM-7090 are of the order of a minute. (auth)

**33239** (GEAP-4244) APPLICATIONS OF STRAIN CYCLING CONSIDERATIONS TO SUPERHEAT FUEL DESIGN. G. F. Rieger (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). June 1963. Contract AT(04-3-)189. 34p.

A potential performance limitation of superheat fuel is the susceptibility of the fuel cladding to low cycle fatigue failure. Two simplified analytical methods are presented to estimate the cyclic lifetime of circular superheat fuel cladding. One failure relation, based on a displacement

method, is of the form $N_f = 0.33\ [(C)/(\Delta\epsilon_p)]^n$, where $N_f$ = cycles to failure, $\Delta\epsilon_p$ = plastic strain range of the power cycle, and C,n = material property constants. The other failure relation, based on a stress method, is of the form $N_f = (1)/(12)\ [(EC)/(S-Se)]^2$, where $N_f$ = cycles to failure, S = elastic stress amplitude of the power cycle, and E, C, Se = material property constants. These relations were compared with data from the literature, and with data involving radiation damage obtained by Reynolds. A recommended design procedure involving the relations is presented. The technique was applied to the SADE 4B experiment with moderate success. These cycling relations involve only mechanical damage imposed by cycling, with a modification for additional damage caused by radiation; they do not include any other potential performance limiting mechanisms, such as stress corrosion, which are normally factored into the over-all fuel design. (auth)

**33240** (GEAP-4303) PROGRAM FOR THE DEVELOPMENT OF PLUTONIUM RECYCLE FOR USE IN LIGHT WATER MODERATED REACTORS. Quarterly Report No. 9, April 1–June 30, 1963. M. A. Robkin and M. P. Lagache (General Electric Co. Vallecitos Atomic Lab., San Jose, Calif.). July 15, 1963. Work Performed under United States Joint Research and Development Program. Contract AT(04-3)-189. 27p. (EURAEC-755)

The project fuel element received an estimated burnup of 831 Mwd/t during the quarter, which brings the total to 3165 Mwd/t. This exposure is as logged by VBWR operating personnel. Applying the same scale factor between logged exposure and Ce–Cs analysis of the first fuel sample gives a corrected exposure of 3774 Mwd/t. The differential solution experiment indicated that less than 1% of the contained plutonium occurred as segregated pure $PuO_2$. The hot spots observed by autoradiography of polished samples of fuel indicated that a substantial fraction of the $PuO_2$ is contained in the hot spots. Super-Ortho-Press plates were used to make enlargements of autoradiographs of polished unirradiated fuel pellets. Densitometer measurements were made on the enlargements. It was observed that the contrast range on the autoradiographs were too wide to allow the SOP plates to be exposed in the linear region of the D-log E curve for both the hot spots and the solid solution simultaneously. However, a five-minute $\alpha$-exposure of a large hot spot gave the same darkening as a 480-minute $\alpha$-exposure of the background, from which it is possible to infer a corrected value of 82 times for the ratio of the Pu density in the hot spot to that in the background. Further debugging of EPITHERMØS, the epithermal extension of the BNL THERMØS code, was made and a test problem was run. (auth)

**33241** (HW-78131) PROGRAM HACK—CORRECTION TO SENSOR ACTIVITY FOR DECAY AND BURNUP. W. B. Henderson (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 5, 1963. Contract AT (45-1)-1350. 13p.

Program HACK (Hanford Activity Correction Kalculation) is a FORTRAN program which computes the time evolution of a radioactive daughter when a stable parent isotope is exposed to an arbitrary flux history. The exposure is assumed to be produced by alternate periods of arbitrary constant power and zero power for a maximum of 1425 cycles. The atom density of parent and daughter, the correction to $N_1(0)\sigma\ \phi\ t$ required to get the daughter atom density, the flux-time, and the average flux are optionally printed at the end of each cycle, and at the end of exposure for a maximum of 100 flux values corresponding to a reference power level. (auth)

**33242** (KFK-153) THEORY OF DELAYED SUPERCRITICAL EXCURSIONS TO DETERMINE DOPPLER-COEFFICIENTS OF FAST REACTORS. Karl Ott (Kernforschungszentrum. Institut fur Neutronenphysik und Reaktortechnik, Karlsruhe, Germany). June 1963. 18p.

The determination of the prompt power coefficient of a fast reactor by means of special delayed superprompt critical excursions was investigated. If the reactivity is inserted as a fast ramp limited below prompt critical, the changes of the neutron flux after the prompt jump result from the competition of the increase of feed-back and delayed neutrons. The height of the prompt jump and the "slope" of the flux after the prompt jump permit the prompt power coefficient to be determined. In the special case in which the competition is complete, the prompt power coefficient is directly connected to the height of the prompt jump. The accuracy of the method is discussed extensively, and improvements in the accuracy are investigated. The achievable high accuracy can be used to test finer details of the Doppler coefficient theory, e.g., the dependence on temperature and temperature profile and on different fuel compositions in fairly small zones. (auth)

**33243** (ORNL-3379) AN ANALYTICAL MODEL FOR FISSION-PRODUCT TRANSPORT AND DEPOSITION FROM GAS STREAMS. M. N. Ozisik (Oak Ridge National Lab., Tenn.). Aug. 9, 1963. Contract W-7405-eng-26. 50p.

An important mechanism in the transport and deposition of very small particles from gas streams to the surfaces of a conduit is diffusion due to the Brownian movement of particles. The heat-mass analogy is used to describe the diffusion, and equations are derived for the deposition of fission products from a gas stream to wall surfaces as a function of the distance along the conduit. Effects of radioactive decay on the validity of the heat-mass analogy in applying standard heat transfer relations to predict material transfer to wall surfaces are discussed. (auth)

**33244** (ORNL-TM-361(Add.)) DEVELOPMENT OF A GENERAL METHOD OF EXPLICIT SOLUTION TO THE NUCLIDE CHAIN EQUATIONS FOR DIGITAL MACHINE CALCULATIONS. D. R. Vondy (Oak Ridge National Lab., Tenn.). Aug. 12, 1963. Contract W-7405-eng-26. 18p.

A calculational procedure developed previously for the determination of nuclide concentrations at a point in a reactor at successive time intervals was modified and expanded. Provisions were incorporated for calculation of reaction rates and summed reactions. The revised program permits a number of successive changes in reactor operating conditions, such as changes in the ratio of fast-neutron flux to thermal-neutron flux, to be readily incorporated into a calculation. (auth)

**33245** (WAPD-T-1582) REDUCTION OF THERMAL ACTIVATION RATES TO A CONTINUOUS SPECTRUM. W. D. Lanning (Westinghouse Electric Co. Bettis Atomic Power Lab., Pittsburgh). June 1963. Contract AT(11-1)-Gen-14. 11p. (CONF-39-25)

From American Nuclear Society Meeting, Salt Lake City, Utah, June 1963.

Information on thermal activation can be accumulated by activating various types of materials, thus enabling the unknown spectrum from which the activations were induced to be inferred. In the Trice-Hartmann technique used the trial functions are linear combinations of the activation cross sections and can be orthogonalized provided the cross sections are linearly independent. Wigner-Wilkins spectra were chosen as trial functions, each of which represents different degrees of hardness. Results of cal-

culations indicated that it is quite plausible to obtain the thermal spectrum from a set of appropriately chosen activation measurements. (M.C.G.)

**33246** THE KINETICS OF A HOMOGENEOUS, BOILING-WATER REACTOR. V. K. Zavoiskii. At. Energ. (USSR), 14: 579-80(June 1963). (In Russian)

The rate of change in vapor content in the active zone of a reactor was estimated for the case of a surge in reactivity. It was assumed that the number of vapor bubbles is constant, and that the change in vapor volume is determined by the rate of increase in volume of all the bubbles present in the moderator before the power surge. It was found that the relative change in volume with time is given by the following expression: $v(t) = \Delta V''(t)/V_0'' = (3\beta/a\bar{R}_0^2) \int_0^t \Delta T\,(dt)$. Here, $\beta$ is equal to $\sqrt{2/\pi}\ (e\gamma'/r\gamma'')\ (au)^{0.5}$, where e, $\gamma'$, and a are the heat capacity, density, and thermal conductivity of the liquid. The term r is the heat of vaporization, u is the velocity of the bubble with respect to the liquid, $R_0$ is the bubble radius, and $\Delta T$ is the liquid superheat. The reactor reactivity consists of an increase in reactivity due to the power surge $\Delta k_{pow.}$ and a negative reactivity due to vapor formation in the moderator $\Delta k_{vap.}$. If the instantaneous excess power reactivity $\Delta k_{pow.}$ is given, the vapor content compensating this reactivity can be calculated, and the maximum time for the formation of this amount of vapor can be determined. If $\Delta k_{pow.}$ is equal to the fraction of delayed neutrons, it can be calculated that $v_{max.} = 0.15$ and $t_{max.} \cong 10^{-2}$ seconds. Thus, an instantaneous excess reactivity causing a 15 to 20% change in vapor volume will be compensated within a few hundredths of a second, and the reactor will not run away. (TTT)

**33247** THE MANUFACTURE OF $UO_2$ FUEL ELEMENTS BY VIBRATION-COMPACTION METHODS. F. Hofmann, H. Kroll, B. Liebmann, and O. Neumann (NUKEM Nuklear-Chemie und Metallurgie GmbH, Wolfgang, Ger.). Ber. Deut. Keram. Ges., 40: 146-52(Feb. 1963). (In German)

With the intention of developing simple and cheap methods of producing $UO_2$ fuel elements, a $UO_2$ powder was placed in cans and compacted. In this method the particles are induced mechanically to move into such close positions that the highest possible compaction is reached. However, this will lead to an adequate total density of the fuel only if the compact powder has a suitable grain-size distribution. Such powders were produced by melting $UO_2$ in a H arc and grinding the hardened material. By vibrating and hammering round, densities of 92% of the theoretical value were reached. (auth)

**33248** THE MANUFACTURE AND USE OF URANIUM MONOCARBIDE FOR FUEL ELEMENTS. P. Himmelstein, B. Liebmann, and L. Schaefer (NUKEM Nuklear-Chemie und Metallurgie GmbH, Wolfgang, Ger.). Ber. Deut. Keram. Ges., 40: 153-8(Feb. 1963). (In German)

An investigation was carried out on the production of UC and its further processing by melting and casting. The carbide was produced by reacting $UO_2$ with powdered graphite at 1700°C in vacuo. The reaction product was melted in an arc furnace and rods, about 120 mm long and 10 to 30 mm in diameter, were cast by the centrifugal process. (auth)

**33249** LESS-KNOWN URANIUM COMPOUNDS AS POSSIBLE NUCLEAR FUELS. F. Thuemmler (Max-Planck-Institut für Metallforschung, Stuttgart). Ber. Deut. Keram. Ges., 40: 159-72(Feb. 1963). (In German)

The production and properties of uranium nitrides, silicides, sulfides, borides, aluminides, beryllide, phosphide, as well as selenide and tellurides, are described. UN appears to be the most important material in the group, $U_3Si_2$, US, $UAl_2$, $UBe_{13}$, and UP also being of interest for certain applications. Selenides and tellurides possess remarkable thermo-electric properties. Since there is so far no nuclear fuel that could be described as ideal, practical application may reveal some advantages of one or another of these less-known materials, either in massive or dispersed form. At present there is only fragmentary information on this group of materials and hardly any on their behavior when irradiated. 146 references are included. (TCO)

**33250** THE EVOLUTION OF STACKING TECHNIQUES AS SEEN FROM SOME PATENTS. J. J. Bonin. Bull. Inform. Sci. Tech. (Paris), No. 71, 27-36(Apr. 1963). (In French)

A detailed analysis was made of a few patents concerning solutions to the problem of Wigner deformations in stacks of solid moderator. Various stackings and their performances were compared. The importance of the French Atomic Energy Commission's solution using longitudinal pins is discussed. (auth)

**33251** STRESS ANALYSIS OF HNPF LOADING-FACE SHIELD. R. D. Chipman, M. D. Lynch, and R. M. Peterson. Exptl. Mech., 2: 193-203(July 1962).

Complex configurations and nonhomogeneous distribution of materials in a massive reinforced-concrete (Fe–limonite) shield for a nuclear reactor made it necessary to supplement theoretical stress analysis by studies of models made of Al, concrete with steel shot aggregate, and plaster. The data obtained was used to determine safety factors. (Rev. Metal Lit., 19: No. 9, Sept. 1962)

**33252** EXPERIMENTAL STRESS ANALYSIS OF A NUCLEAR REACTOR PRESSURE VESSEL. B. L. Greenstreet (Oak Ridge National Lab., Tenn.), F. J. Witt, J. E. Smith, R. L. Maxwell, and L. R. Shobe. Exptl. Mech., 1-11(June 1963).

The stresses from internal pressure in a nuclear-reactor pressure vessel were investigated using both strain-gaged and photoelastic models. The methods used in obtaining complete stress distributions along the nozzles from strain-gage data are described, and comparisons are made between the distributions obtained from the photoelastic model and those derived from strain-gage data. The effects of nonradial attachment of a nozzle to a spherical shell upon the stresses in the nozzle and in the shell are shown. Comparisons are made between the experimental results and those for simplified analytical models. (auth)

**33253** USE AND APPLICATIONS OF CARBON AND GRAPHITE. [PART II]. Ind. Heating, 29: 1143; 1145-6 (June 1962).

The mechanical properties, gas permeability, and irradiation behavior of graphite reactor components were determined by experiments and by in-service observations. (Rev. Metal Lit., 19: No. 10, Oct. 1962)

**33254** PRESTRESSED CONCRETE PRESSURE VESSELS FOR NUCLEAR REACTORS. T. C. Waters and N. T. Barrett (United Kingdom Atomic Energy Authority, Risley, Eng.). J. Brit. Nucl. Energy Soc., 2: 315-25(July 1963).

The design philosophy of prestressed concrete pressure vessels is discussed in some detail. The various components (lining, openings, ligaments, cabling systems) are considered. The design of cylindrical vessels with flat ends, spherical vessels, and cylindrical vessels with spherical ends is considered, and it is concluded that spherical vessels meet the design requirements most fully. The most economic pressure range is found to be 300 to 400 psig for

cylinders and 600 to 800 psig for spheres. The need for model tests for each design is emphasized. A research program should be conducted on the behavior of materials, of parts of vessels, and of complete vessels, and the most important aspects of the behavior to be studied are outlined. (D.L.C.)

**33255** THE WEIGHTING FUNCTIONS OF REACTOR PHYSICS. Jeffery Lewins. J. Brit. Nucl. Energy Soc., 2: 326-34(July 1963).

The equation for the optimum distribution of detectors in a nuclear reactor is derived in a general notation suitable for all the usual models of reactor theory. In the linear case, this equation is shown to be identical with the equation for the importance. The importance, or the contribution of a neutron to a future detectable result, has its equation derived directly from its definition in the same general notation, using the appropriate Green's function. Such a concept leads to a better understanding of the nature of the optimum detector distribution or weighting function. Different weighting functions are compared and their employment discussed. A series of Lagrangians or variational principles are derived from the basis statement of the optimum detector distribution, each with a clear physical significance. These Lagrangians are catalogued in terms of computational power increasing as the model for the reactor behavior is simplified. (auth)

**33256** NUCLEAR APPLICATION OF LEAD. J. F. Holmes. Metal Ind. (London), 101: 42-4(July 20, 1962).

A comparison was made of the efficiency of Pb with paraffin, polythene, polystyrene, lucite, wood, $H_2O$, and concrete as shielding material for atomic reactors. The effects of Ag, Cu, As, Sb, Sn, Zn, Fe, and Bi impurities on the physical and mechanical properties of Pb are discussed. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**33257** NUCLEAR REACTOR SPATIAL KINETICS EXPRESSED IN THE TRANSFER FUNCTIONAL FORM. Shigenori Hayashi (Kyoto Univ.), Tsutomu Hoshino, and Jiro Wakabayashi. Nippon Genshiryoku Gakkaishi, 5: 503-7(June 1963). (In Japanese)

The spatial kinetics of the nuclear reactor has been studied by means of the modal expansion method. The transfer functional expressions of the modal response have also been used. It is, however, rather difficult to do the practical calculation or have an intuitive understanding of the flux response by means of the modal expansion, in which the solutions are expressed through the eigenvalues and the eigenfunctions. In the control engineering field, it may be required to get rough information, such as the equivalent simple lag approximation, rather than the strict or accurate one about the response. For this reason, the Green's function of the diffusion equation of the bare, zero power reactor (slab and cylinder, one dimensional) is obtained under the specified boundary conditions, in order to get more convenient expressions of the spatial kinetics. The Green's function also means the transfer function describing the relation between the point neutron source and the neutron flux response. This transfer function is approximated as the simple rational function of "s" and its physical meaning discussed. Numerical examples of the strict frequency response of the reactor flux and the dependency on the space variable are shown. (auth)

**33258** DEVELOPMENT OF REACTOR FUELS IN CANADA. A. J. Mooradian. Nippon Genshiryoku Gakkaishi, 5: 526-30(June 1963). (In Japanese)

**33259** REACTOR SAFETY. J. F. Ablitt. Nucl. Eng., 8: 286-7(Aug. 1963).

Reactor safety is divided into three components — safety of the public, safety of the operating staff, and safety of the plant itself. Each component, along with its own set of factors, is considered. (R.E.U.)

**33260** TECHNICAL NEWS OF WELDING OF A REACTOR FOR ELECTROTHERMAL NUCLEAR PLANT. Carlo Tissi, Giovanni Popoli, and Giuseppe Paris. Riv. Ital. Saldatura, 14: 193-215(1962). (In Italian)

Techniques for welding, brazing, plating, and ultrasonic testing of Case 1236 steel reactor components at Garigliano River (Italy) are reported. Determination was made of physical, chemical, and mechanical properties of the material employed. (Rev. Metal Lit., 19: No. 12, Dec. 1962)

**33261** BORON-CONTAINING STAINLESS STEEL FOR NUCLEAR REACTORS. E. S. Levinson. Stal, No. 7, 648-9(1962).

Investigations were made on electric arc melting of austenitic Cr–Ni stainless steel; and alloying with additions of 0.15 to 2.1% B and forging at 1150°C. Tests were made on the influence of B on microstructure, weldability, corrosion resistance, mechanical properties, yield strength, yield point, embrittlement, relative contraction and expansion, resilience, hardness, and creep. Suitability of the steel for heat shields in nuclear reactors was also investigated. (Atomdokumentation 5: No. 9, May 1963)

**33262** THE FABRICATION, PROPERTIES AND IRRADIATION STABILITY OF DISPERSION-TYPE FUELS. D. T. Livey (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram. Soc., 62: 197-220(1963).

A dispersion-type fuel is defined and the advantages that might be gained by the use of such fuels are outlined. Two types of fuels are considered: oxide- and carbide-based. The carbide fuel is illustrated by the carbon-coated carbide fuel particle and the fabrication of such particles is briefly described. The oxide fuel is illustrated by the systems $BeO-UO_2$, $Al_2O_3-UO_2$, and $MgO-UO_2$, and the fabrication of such fuels is also considered. The properties of the various materials and the problems that exist with regard to phase stability, relative thermal expansion, thermal conductivity, and permeability are outlined. The dimensional stability of dispersed fuels under irradiation is considered and available information on the problem is presented. (auth)

**33263** SYMPOSIUM ON NUCLEAR CERAMICS — INTRODUCTION. P. Murray (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram. Soc., 62: 71-81(Feb. 1963).

The application of ceramics in nuclear reactors is reviewed, the major emphasis being on the use of ceramic-type materials such as $UO_2$ and UC as fuels. The irradiation behavior of the materials, both in bulk form and in dispersed forms, is also discussed with reference to fission gas release, both as a function of burn-up and also as a function of temperature. The availability of Pu from the large natural U plants, leading to its use as enrichment in fast reactor fuels, is also referred to with its impact on ceramic fuels research. The major emphasis on more conventional ceramic materials is concentrated on beryllia, with its behavior under irradiation receiving most attention. Finally, attention is drawn to the need for further studies of the basic mechanisms of greater initiation and propagation in the materials because of their brittle properties and poor resistance to thermal shock. (auth)

**33264** IRRADIATION EFFECTS IN URANIUM AND PLUTONIUM CERAMICS. J. B. Sayers (Atomic Energy Research Establishment, Harwell, Berks, Eng.). Trans. Brit. Ceram Soc., 62: 139-57(Feb. 1963).

The effects of irradiation on dimensional changes due to fission-fragment damage and accumulation of fission products, cracking and structural changes, thermal conductivity, release of fission products, and effect of Pu additions on $UO_2$ are discussed. (TCO)

**33265** PROPERTIES OF URANIUM MONOCARBIDE. D. J. Brown and J. J. Stobo (C.A. Parsons and Co. Ltd., Newcastle upon Tyne, Eng.). Trans. Brit. Ceram. Soc., 62: 177-82(Feb. 1963).

Some of the properties of UC relevant to its use as a fuel for either thermal or fast reactors were evaluated. The oxidation resistance of cast UC is shown to be superior to that of U metal above about 550°C in $CO_2$, and above about 200°C in air containing 1 wt % $H_2O$. In $CO_2$ at 800°C, even porous sintered UC is more resistant than U. Good compatibility with liquid Na (containing 10 ppm O) is reported, after 6 weeks at 600 and at 750°C. Hot-hardness values drop from 700 VPN at 300°C to 50 VPN at 1000°C. (auth)

**33266** INTRODUCTORY NUCLEAR REACTOR THEORY. Herbert S. Isbin. Reinhold Chemical Engineering Series. New York, Reinhold Publishing Corp., 1963. 635p. $22.50.

The material is introduced by a review of basic aspects of reactor concepts, engineering problems, and nuclear reactions. Studies are then made of neutron moderation and diffusion, nonmultiplying media, characteristic dimensions and theory, transport theory, dynamics, perturbation theory, multigroup methods, and several types of reactors (viz. bare, critical, homogeneous reactors; reflected reactors; and heterogeneous and homogeneous thermal reactors). (T.F.H.)

**33267** PROCEEDINGS OF FRANCE-JAPAN CONFERENCE ON NUCLEAR TECHNOLOGY, TOKYO, NOV. 12-14, 1962. (Association Technique pour l'Energie Nucléaire, Paris and Japan Atomic Industrial Forum, Inc., Tokyo). 262).

A total of thirty-two papers are presented on various topics related to nuclear power reactors. The topics include the French nuclear program, Chinon, radioisotope applications, fuel reprocessing, graphite, G2 and G3 reactors, reactor safety, concrete pressure vessels, and atomic energy development in Japan. The technical papers were previously abstracted in NSA. (D.L.C.)

**33268** RESEARCH ON THREE-DIMENSIONAL SIMULATION OF NUCLEAR REACTORS. G. P. Caligiuri (Euratom, Brussels), W. Claes, H. d'Hoop, and R. Vichnevetsky. p.322-7 of "Third International Analogue Computation Meetings." Brussels, Presses Académiques Européennes, 1962. (EUR 213.f) (In French)

A set of investigations was undertaken with a view to determining the best methods of spatial representation of nuclear reactors, from the viewpoint of programmation ease as well as those of accuracy and bulk of material required for their being materialized on an electronic analog computer. These investigations were undertaken on a graphite-moderated and gas-cooled nuclear reactor of the natural uranium type, simulating, on the one hand, axial transitory behavior, and, on the other hand, radially azimuthal transitory behavior; their aim is to establish and to test computing methods for resolving the partial-derivative equations occurring in reactor studies. In the two cases, the method of finite differences and the method of proper functions were used with the aim of comparing respective merits and drawbacks of the two. Results so obtained have permitted one to draw a conclusion as to the choice of the best mathematical model which should be made in order to achieve three-dimensional simulation of this reactor type. (auth)

**33269** THE REACTOR OPERATOR'S APPROACH TO NUCLEAR MATERIAL MANAGEMENT. Richard A. Cordin (Yankee Atomic Electric Co., Boston). 14p. (CONF-80-1)

From Inst. of Nuclear Materials Management Annual Meeting, Buffalo, June 1963.

A discussion is presented of the management of fuel materials by reactor operators and processors. The management comprises knowledge of the amount burned in the reactor, of the amounts sent to other firms for processing, etc. The problems of shipper-receiver differences and varying enrichments are mentioned, and the importance of management of nuclear materials is emphasized. Monthly balances and standardized accountability ledgers are suggested as practical means for improving the management situation. (D.L.C.)

**33270** NON-METALLIC FUEL ELEMENTS. R. Caillat (CEN, Saclay, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/71, 5p. (CONF-120-24). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Recent attainments in the physicochemical properties, possibilities for the fabrication, and the effects of radiation on non-metallic fuels, such as uranium carbides and $UO_2$, are discussed. (P.C.H.)

**33271** STUDY OF THE PREPARATION OF SINTERABLE URANIUM DIOXIDE FOR THE FABRICATION OF FUEL FOR THE EL-4. R. Delmas and J. Holder (CEA, Ballancourt-sur-Essonne, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/65, 19p. (CONF-120-21). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The preparation by reduction of the 20 tons of enriched U required for the initial loading of the EL.4 reactor is described. The qualities of the $UO_2$ obtained are shown to depend not only on the conditions of reduction but also on those of precipitation and calcination of the intermediate products between the nitrate and the higher oxide. Particular attention is paid to carrying out reduction under exactly defined conditions. This is possible owing to the use of a revolving tube, continuous-operation apparatus. Owing to regular contact between the solid and the reducing gas, which permits excellent heat exchange, the $UO_2$ prepared by this method is very homogeneous and well suited to sintering. The apparatus as designed and constructed can produce 10 kg of $UO_2$/hr. Some hundreds of kg of $UO_2$ were prepared and sintered on an industrial scale. The average density of the sintered pellets is 10.5. Density is never less than 10.4 and for certain dioxides may reach 10.8. This reducing technique can also be used for preparation of dioxides to be shaped by cold extrusion. (P.C.H.)

**33272** RELEASE OF FISSION PRODUCTS FROM UC-ZrC FUEL INSERTS. F. Barth (Brown-Boveri/Krupp Reaktorbau GmbH, Duesseldorf), C. B. von der Decken, K. Schifferstein, A. Clauss, H. Reichel, J. Rygaert, and W. R. Ruston. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/44, 35p. (CONF-120-15). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The release of fission products from pellets of the approximate composition UC + 20 ZrC was investigated in a loop during irradiation. The purpose was to check the possibility to use these pellets as inserts for the spherical fuel elements of a HTR. Tests were carried out on free pellets and on pellets enclosed in graphite capsules. Some pellets had a 1 to 2-mm-thick border zone consisting of pure Zr carbide. The samples were placed in electric resistance furnaces reaching a maximum temperature of 1600°C. The neutron fluxes during irradiation were 3 to $4 \times 10^{10}$ n/cm$^2$/sec. The loop permitted measurements on the release $Kr^{85m}$, $Kr^{87}$, $Kr^{88}$, $Xe^{133}$, and $Xe^{135}$ during irradiation and the indirect determination of $I^{133}$ and $I^{135}$ after shutdown of the reactor. The minimum release of $I^{131}$, $Sr^{89}$, $Ba^{140}$, and $Ce^{141}$ was radiochemically determined after withdrawal of the specimen. It was also possible to measure the recoil fraction $\epsilon_R$ alone when the fuel insert was suspended within a furnace of larger diameter. The measured values of $\epsilon_R$ were only slightly higher than the calculated ones. At higher sample temperatures the diffusion fraction $\epsilon_D$ could be calculated by subtraction of the recoil fraction from the total release. From $\epsilon_D$ it was possible to calculate $D/r_0^2$ (sec$^{-1}$) using approximation equations where D = diffusion constant, $r_0$ = mathematically defined mean particle radius. The logarithmic plot of these values against 1/T yielded the activation energies (T = sample temperature in °K). (P.C.H.)

**33273** IN-PILE MEASUREMENTS OF DIFFUSION OF FISSION PRODUCTS THROUGH IMPREGNATED GRAPHITE SHELLS OF FUEL ELEMENTS. F. Barth (Brown-Boveri/Krupp Reaktorbau GmbH, Duesseldorf), C. B. von der Decken, K. Schifferstein, A. Clauss, H. Reichel, J. Rygaert, and W. R. Ruston. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/43, 29p. (CONF-120-14). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The influence of various impermeabilization treatments of graphite shells, which serve simultaneously as moderator and canning, upon the release of fission products from the fuel elements was investigated. Each fuel element was irradiated for 11 days in a neutron flux of $4.10^{10}$ n/cm$^2$/sec and under simultaneous heating to a temperature of 1000°C. During irradiation, the fuel elements were either free in circulating He or embedded in granulated graphite within closed steel capsules. The free fuel elements allowed the measurement of the build-up in the circulating gas of the activities of $Kr^{87}$, $Kr^{88}$, $Kr^{85m}$, $Xe^{135}$, and $Xe^{133}$ during irradiation. Puncturing of the steel capsules after irradiation gave the total of $Kr^{85m}$, $Xe^{135}$, and $Xe^{133}$ released from the encapsulated fuel elements. The distribution of the concentration of the fission products $I^{131}$, $I^{133}$, $Te^{132}$, $Sr^{89}$, $Ba^{140}$, and $Ce^{141}$ in the graphite shells of the fuel elements as well as their activities in the granulated graphite were determined after irradiation. The experiments showed that the isotopes $Sr^{89}$, $Ba^{140}$, and $Ce^{141}$ do not diffuse appreciably in the graphite shells, but are formed in situ through disintegration of the diffusing rare gas precursors. The distribution curves of the isotopes were therefore proportional to the stationary distribution of the rare gas isotopes $Kr^{89}$, $Xe^{140}$, and $Xe^{141}$ and it was possible to determine the diffusion constants and the stay periods of the rare gases in the graphite shells. The investigations also showed that the rare gases diffuse within a few seconds through an unimpregnated graphite shell about 2 cm thick. (P.C.H.)

**33274** INTERESTING DEVELOPMENTS IN $UO_2$ TECHNOLOGY. J. A. L. Robertson (Atomic Energy of Canada Ltd., Chalk River, Ont.). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/25, 37p. (CONF-120-13). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

A review is presented on developments in $UO_2$ technology. Thermal conductivity, sheath elongation, release of fission product gases, and in-reactor measurements on $UO_2$ are discussed. (P.C.H.)

**33275** HOT PRESSED BERYLLIUM OXIDE BRICKS AS NEUTRON REFLECTORS. R. Beauge, J. Elston, and R. Roulliay (CEN, Saclay and Fontenay-aux-Roses, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/15, 18p. (CONF-120-10). (In French)

Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

Study of the effects of neutron irradiation on the physical properties and mechanical characteristics of BeO shows that irradiation temperature, density of the oxide, and shape of the grains of the sintered compacts determine how the refractory substance will be used as a moderator in reactors operating at high temperature. There is a critical decline in the mechanical characteristics of the dense BeO compacts following irradiation of the order of $2 \times 10^{20}$ $n_f$/cm$^2$ (E > 1 Mev) at below 100°C. However, the behavior of hot pressed BeO bricks used as a reflector in a swimming pool reactor was studied. For this purpose, tight Al vessels containing compacts of high density (~ 2.9) were constructed and three of them, about 150 kg of BeO, formed part of the reflector of the Triton swimming-pool reactor. In stable operation, the power of the reactor is 2 Mw. The instantaneous fluxes reaching the surface of the vessel closest to the core are $2 \times 10^{13}$ $n_{th}$/cm$^2$/sec and $10^{12}$ $n_f$/cm$^2$/sec, respectively. Temperature measurements made under these conditions gave 70°C for the hottest points of the compacts. The most heavily irradiated vessel remained in service for 11,495 hrs. The condition of the bricks after being used is described. (auth)

**33276** FABRICATION AND PROPERTIES OF CYLINDRICAL AND TUBULAR $UO_2$/STAINLESS STEEL FUEL ELEMENTS. L. Meny, M. Champigny, and P. Guyader (CEN, Saclay, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/13, 56p. (CONF-120-9). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The fabrication by extrusion sintering of canned tubes and rods containing a dispersed fuel nucleus of $UO_2$/stainless steel was investigated. The fuel elements may be up to 2 m long; the diameter of the rods is less than 30 mm; the total thickness of the tubes may be as low as 0.8 mm. The fuel cermet contains 20 to 60% $UO_2$ by weight in the form of spherical particles having a diameter greater than 50 μ. The grade of steel for the cermet can be chosen in relation to the conditions in which it is to be used. The fuel elements are checked by gammagraphy, macrography, and micrography. The thermal conductivity and mechanical tensile properties of the cermets were investigated in relation to $UO_2$ content and particle granulometry. Thermal shock tests and lengthy annealing of the tubular elements caused no cracking or lessening of the can. By this method of extrusion sintering canned fuel elements can be directly obtained; handling of the $UO_2$ powder is reduced to a minimum, so that the losses of enriched U in the industrial fabrication of the fuel elements can also be reduced. (auth)

**33277** THE INDUSTRIAL PRODUCTION OF URANIUM OXIDE SUITABLE FOR SINTERING AT THE BOUCHET

PLANT. M. Delange (CEA, Ballancourt sur Essonne, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/9, 21p. (CONF-120-7). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The production of $UO_2$ suitable for sintering by the reduction of trioxide obtained by the calcination of a precipitated ammonium uranate is described, along with the different types of equipment used and the precipitating, filtration, calcination, and reduction processes. The characteristics of the products obtained are given, together with the results of the sintering operations (laboratory tests or industrial fabrication) for the different varieties of dioxide obtained. (auth)

**33278** FUSION BY ELECTRONIC BOMBARDMENT AND CONTINUOUS CASTING-METHOD FOR SHAPING SEMI-METALLIC NUCLEAR FUELS. A. Accary and J. Trouve (CEN, Saclay, France). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/7, 43p. (CONF-120-5). (In French)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

The method of using electronic bombardment heating in continuous casting shaping semi-metallic rods of nuclear fuels such as UC, $UC_2$, $ThC_2$, and $(Th,U)C_2$ is discussed. In relation to casting conditions, investigations were made on impurity content, crystallization, and the accessible dimensions of the bars. A fabrication cycle is suggested and use of the process for industrial application is indicated. (P.C.H.)

**33279** DEVELOPMENT OF PRODUCTION SCALE PROCEDURES FOR COATING FUEL PARTICLES. F. Benesovsky (Metallwerk Plansee Aktiengesellschaft, Reutte/Tyrol, Austria). Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/1, 15p. (CONF-120-1). (In English)

From Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963.

A process as well as the necessary equipment for the production of graphite-coated fuel particles were developed. Initially, the tumbling method was used but later on merely the fluidized bed approach was employed. After testing various nozzle forms, an operator in conjunction with a high-frequency heated graphite reactor was constructed that permits coating temperatures even in excess of 2000°C. The system was built in the most practical manner in order to facilitate servicing of the apparatus. A semi-automatic apparatus was developed that also permits the application of multiple layers. The automatic setting of even a complicated coating program renders the apparatus particularly suitable for production purposes because it makes possible the production of the small single charges of greatest uniformity that are necessary when $U^{235}$ is used. (auth)

**33280** REMOVAL OF $S^{35}$ AND $P^{32}$ FROM ORGANIC MODERATOR-COOLANTS. James F. Black and Mervin E. Conn (Esso Research and Engineering Co., Linden, N. J.). 20p. (CONF-14-3)

From American Chemical Society Meeting, Los Angeles, Mar.-Apr. 1963.

Radioactive $S^{35}$ and $P^{32}$ constituents are generated from the natural sulfur in organic coolants during exposure of the coolant to the neutron flux in nuclear power plants. On-site removal of these radioactive constituents, present in extremely low concentration, in preference to the nonradioactive S compounds, present in much higher concentration, would permit improved plant operation and economy. The results of laboratory tests, designed to assess the ability of adsorbents to do this job, are highly favorable. For example, tests with a nickel catalyst show 88% removal of radioactive constituents and only 20% removal of nonradioactive sulfur at 100 W/W in a 1-pass operation and possibly about the same at 500 W/W in a 2-pass operation. The degree of success achieved thus far appears to be of significant practical value. (auth)

**33281** OPTIMUM REACTOR SHIELDING. S. Pawlicki (Westinghouse Electric Corp., Pittsburgh). 24p. (CONF-9-5)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Some developments in the design of the primary, refueling, and containment shields for pressurized water reactors are reviewed. Yankee shielding performance is described, followed by a discussion of potential cost reductions in providing adequate radiation protection. Starting from the definition that the optimum reactor shielding is equivalent to providing an adequate radiation protection at a minimum cost, it may be concluded that: radiation is just another design element, like pressure or temperature, and cannot be considered separately; and reactor shielding optimization depends strongly on plant siting criteria and the reactor containment shield. (auth)

**33282** CORE COMPONENT DESIGN FOR MINIMUM MANUFACTURING COST. M. Rodinos. 15p. (CONF-9-4)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

The design of the calandria and end shields for the CANDU reactor is analyzed with respect to cost, and areas of cost improvement are suggested. High-cost areas encountered during the fabrication of the core components are pointed out. "Nuclear quality" is a very high-priced commodity. It is suggested that the relaxation of dimensional tolerances is the most probable place to achieve cost reductions. Minimum manufacturing costs can be achieved only when knowledge and experience have moved the fabrication of nuclear components from a prototype to a production status. (M.P.G.)

**33283** IMPROVEMENTS RELATING TO BOILING MODERATOR REACTORS. (to General Electric Co.). British Patent 930,655. July 10, 1963. Priority date Nov. 4, 1958, United States.

The design of a reactor fuel element is patented, which is designed to overcome the problem of warped flux and power distributions in a boiling moderator reactor. The total fissile and fertile atom content per unit length decreases, but the fissile atom content per unit length is substantially uniform along the length of the fuel element. This is achieved by constructing an elongated fuel element from a plurality of axially aligned fuel pellets, which are either solid or hollow but have equal fissile atom content. The variation in the average number of hollow fuel pellets per unit length of fuel element is arranged to provide flattened pseudo-square-wave neutron flux and power distributions through the core. (M.P.G.)

**33284** IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTOR FUEL ELEMENTS. James Benn, Frank Butler, Kenneth Henry Dent, Arthur Chesworth, Kenneth Foster, William Charles Leonard Kent, Brendan Orrell, William Selwyn Robson, Thomas Arthur Seeley, and Ernest Smith (to United Kingdom Atomic Energy Authority). British Patent 930,661. July 10, 1963. Filed Mar. 2, 1960.

A reactor fuel element provided with a device to prevent vibration due to the flow of coolant in the fuel channel is patented. The fuel element is of elongate form, and its ends are designed so that a series of fuel elements can be stacked upon one another in a vertical channel. At one end of the fuel element, radial support members are provided, at least one of which can be radially extended and retracted by sliding relative to the fuel element. The sliding member is held in a retracted position by a spring until it is forced outward by the end of the adjacent fuel element. The sliding member extends until the support members contact the wall of the channel and stabilize the fuel element. The fuel-element is especially designed for gas-cooled reactors. (M.P.G.)

**33285** IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTOR FUEL ELEMENTS. William Selwyn Robson, Kenneth Henry Dent, and William Charles Leonard Kent (to United Kingdom Atomic Energy Authority). British Patent 930,662. July 10, 1963. Filed Mar. 2, 1960.

A reactor fuel element provided with a device to center the element and prevent vibration due to the flow of coolant in the fuel channel is patented. The fuel element is of elongate form and has a cup-shaped recess at its upper end adapted to be engaged by a cone at the lower end of the next fuel element above it in the stacked column. One end of the fuel element is provided with radially projecting arms, one of which is extensible by some means such as a spring-loaded bellows. The arm extends until it contacts the wall of the channel, thereby moving the fuel element until the other arms also contact the channel wall and the element is centered and stabilized. The extensible arm can be retracted by the fuel-element-handling grab. The fuel-element design is especially applicable to gas-cooled reactors. (M.P.G.)

**33286** IMPROVEMENTS IN OR RELATING TO NUCLEAR FUEL ELEMENTS. Ernest Smith (to United Kingdom Atomic Energy Authority). British Patent 930,663. July 10, 1963. Filed Mar. 2, 1960.

A reactor fuel element provided with a device to prevent vibration due to the flow of coolant in the fuel channel is patented. The fuel element is of elongate form, and its ends are designed so that a series of fuel elements can be stacked upon one another in a vertical channel. Several radial support members are pivotably mounted on one end of the element. The weight of an element above it causes the support members to extend radially until they contact the walls of the channel, thereby stabilizing the element. The fuel-element design is especially applicable to gas-cooled reactors. (M.P.G.)

**33287** IMPROVEMENTS IN OR RELATING TO FUEL ELEMENTS. Michael Lesney Noakes (to United Kingdom Atomic Energy Authority). British Patent 930,850. July 10, 1963. Filed Dec. 16, 1960.

A process is patented whereby a temperature-measuring device may be incorporated in a sheathed fuel plate or any object produced by multiple rolling operations. A wire is inserted in a prepared aperture before the first rolling stage and removed after the first rolling stage. This is repeated with wires of gradually decreasing diameter. After the penultimate rolling stage, the temperature-measuring device is inserted, and the plate is rolled to final thickness. The wires are prepared for insertion by shot blasting with steel shot to provide a key for a lubricant, which is preferably graphite. (M.P.G.)

**33288** NUCLEAR FUEL ELEMENT. (to Combustion Engineering, Inc.). British Patent 931,006. July 10, 1963. Priority date Mar. 31, 1959, United States.

An improved ceramic fuel element, which can be operated at high burnups, is patented. The ceramic fuel is diluted with another ceramic of low neutron absorption cross section. The fuel element consists of a protective casing containing a fuel that is a homogeneous face-centered cubic solid solution of from 5 mole % to 55 mole % $UO_2$ in stabilized $ZrO_2$. Stabilized $ZrO_2$ maintains the face-centered cubic crystalline form from room temperature to the melting point. (M.P.G.)

**33289** IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTORS. (to Babcock and Wilcox Co.). British Patent 931,286. July 17, 1963. Priority date Dec. 2, 1958, United States.

A reactor fuel element with a metal sheath containing burnable poisons is patented. The poison is homogeneously distributed in the metal, which is preferably stainless steel, and may be B, Eu, or any material producing a total neutron capture cross section equal to that produced by B distributed in a proportion by weight of not less than 200 parts and not more than 1000 parts/million parts of metal. This controls excess reactivity in the fuel elements when they are first used and minimizes the amount of control apparatus required for the operation of the reactor. (M.P.G.)

**33290** COOLING MEDIUM CIRCULATION SYSTEMS FOR NUCLEAR REACTORS. (to Brown, Boveri & Cie, AG and Beteiligungs-und Patentverwaltungesellschaft mit Beschrankter Haftung). British Patent 931,362. July 17, 1963. Priority date Apr. 28, 1959, Germany.

A method for preventing leaks in the coolant-circulating system of a double-walled reactor is patented. The coolant is circulated by an impeller mounted in a housing forming an extension of the inner wall and driven by a motor mounted in a stationary position outside the walls of the reactor. The shaft passing through the reactor walls must have gas-tight seals, which are difficult to obtain because the inner and outer walls of the reactor are displaced relative to each other by thermal expansion and contraction. To compensate for the displacement, the shafts between the impeller and the motor are provided with a combination of universal joints and splines. (M.P.G.)

**33291** IMPROVEMENTS IN OR RELATING TO NUCLEAR REACTORS. Philip Cloudsley Warner (to Atomic Power Constructions Ltd.). British Patent 931,552. July 17, 1963. Filed July 31, 1959.

A restrictor for a vertical coolant channel of a gas-cooled reactor is patented. The removable restrictor is forced against a fixed location member and held in position by the static pressure around the restrictor, the static pressure from the downward component of the momentum force of the gas stream, and the weight of the restrictor. The restrictor does not need a mechanical locking device and can be removed or replaced by straightforward grab apparatus. (M.P.G.)

**33292** IMPROVEMENTS RELATING TO NUCLEAR REACTORS. Frank Marshall (to United Kingdom Atomic Energy Authority). British Patent 931,608. July 17, 1963. Filed Nov. 17, 1961.

A method for promptly detecting and isolating a breached fluid-coolant pressure circuit in a reactor is patented. A device sensitive to the flow velocity of the fluid coolant is provided in each pressure circuit. An indication of abnormally high velocity automatically initiates a mechanism to close the inlet and outlet valves in the circuit and at the same time makes the mechanisms in the other pressure circuits inoperative. The reactor could also be shut down at the same time. (M.P.G.)

**33293** IMPROVEMENTS IN OR RELATING TO LIQUID MODERATOR NUCLEAR REACTORS SUBJECT TO VARYING MOVEMENTS. (to Commissariat a l'Energie Atomique). British Patent 931,779. July 17, 1963. Priority date Aug. 22, 1958, France.

A method for reducing irregularities in the operation of a liquid-moderated reactor subject to varying movements, such as those encountered on a ship, is patented. A flow-control device in the moderator circuit regulates the delivery of the moderator to the reactor to compensate for variation in the density of the moderator liquid in the reactor vessel due to acceleration of the vessel. The flow-control device increases the moderator flow when the density decreases, and decreases flow when the density increases. Regulation may be effected by a mass, which is displaceable by acceleration and varies the flow cross-section of the recycled liquid. Various designs for the flow-control device are described. (M.P.G.)

**33294** NUCLEAR FUEL ELEMENT AND METHOD FOR ITS FABRICATION. R. Eugene Droegkamp, A. Fremont Steeves, and F. George Stengel (to U. S. Atomic Energy Commission). German Patent 1,148,028. May 2, 1963. Priority date July 28, 1958, United States.

A reactor fuel element is described consisting of an elongated flat metallic core of fissile material enclosed in a metallic sheath. The fuel element is fabricated by sandwiching the fuel core between the two sheets of the sheath and effecting a metallurgical bonding of the sheath and the core by hot rolling or similar technique. It is difficult to maintain the dimensional specifications of the core during the bonding operations. To overcome these difficulties, the fuel core is beveled at the edges, and the sheets are provided with grooves so that the core fits tightly into the sheets. (Gmelin Inst.)

**33295** METHOD AND PLANT FOR CONTROLLING THE POWER OF A NUCLEAR SUSPENSION REACTOR WHEN CONSTANTLY DIMINISHING THE LOAD. J. Antonius Hendrikus Kersten (to Stichting Reactor Centrum Nederland). German Patent 1,149,467. May 30, 1963. Priority date Dec. 30, 1960, Netherlands.

In the event of abnormal reactor power oscillations unlike the normal statistical oscillations (noise), an electrolyte is added to the circulating suspension to alter the hydrogen and/or deuterium ion concentration. The electrolyte is preferably added according to abnormal variations of the neutron flux. (Gmelin Inst.)

**33296** NUCLEAR REACTOR WITH FUEL UNDER SPHEROIDAL FORM. Andre Huet. U. S. Patent 3,098,809. July 23, 1963. Priority date July 9, 1958, France.

A method of utilizing fissionable matter as nuclear fuel in the form of small spheres or ovoid balls with 2- to 3-cm diameter is described. Each ball is contained in a jacket having thin walls permeable to neutrons. The jacket can consist of several portions, each with flanged edges that can be welded together. The welded edges can be jigsawed in such a manner as to establish a kind of fins all around the sphere. The fins maintain normal spacing of the spheres and permit effective heat diffusion. The central portion of the sphere may be free of fissionable matter. This space can be established by a graphite ball or a hollow metal sphere. The spheres can be arranged in cylindrical baskets, which can be mounted in the reactor on devices permitting modifying the spaces between the baskets. (A.G.W.)

**33297** VAPOR PRESSURE WATER BOILER REACTOR. William N. McElroy and Grant O. Haroldsen (to North American Aviation, Inc.). U. S. Patent 3,098,810. July 23, 1963. Filed Aug. 20, 1956.

A method of operating an aqueous solution-type reactor is described, which comprises maintaining the core of the reactor at a pressure substantially below atmospheric pressure during operation, catalytically recombining radiolytic hydrogen and oxygen, and returning the resulting water to the reactor core. An operating pressure essentially equal to the sum of the vapor pressure of the core solution and the partial pressure of the radiolytic gases may be obtained by initially drawing a vacuum on the core and then permitting the pressure to be governed by the operating temperature of the core solution and the evolved radiolytic gases. At low power a relatively simple internal recombiner can be used, and at higher powers an improved closed-cycle external recombiner is provided. (A.G.W.)

**33298** FUEL COMPOSITION FOR NUCLEAR REACTORS. James C. Andersen (to U. S. Atomic Energy Commission). U. S. Patent 3,100,183. Aug. 6, 1963.

A process for making refractory nuclear fuel elements involves heating uranium and silicon powders in an inert atmosphere to 1600 to 1800°C to form $USi_3$; adding silicon carbide, carbon, 15% by weight of nickel and aluminum, and possibly also molybdenum and silicon powders; shaping the mixture; and heating to 1700 to 2050°C again in an inert atmosphere. Information on obtaining specific compositions is included. (AEC)

**33299** REFLECTOR FOR NEUTRONIC REACTORS. A. P. Fraas (to U. S. Atomic Energy Commission). U. S. Patent 3,100,187. Aug. 6, 1963.

A reflector for nuclear reactors that comprises an assembly of closely packed graphite rods disposed with their major axes substantially perpendicular to the interface between the reactor core and the reflector is described. Each graphite rod is round in transverse cross section at (at least) its interface end and is provided, at that end, with a coaxial, inwardly tapering hole. (AEC)

**33300** REACTOR MODERATOR STRUCTURE. A. P. Fraas and J. J. Tudor (to U. S. Atomic Energy Commission). U. S. Patent 3,100,188. Aug. 6, 1963.

An improved moderator structure for nuclear reactors consists of moderator blocks arranged in horizontal layers to form a multiplicity of vertically stacked columns of blocks. The blocks in each vertical column are keyed together, and a ceramic grid is disposed between each horizontal layer of blocks. Pressure plates cover the lateral surface of the moderator structure in abutting relationship with the peripheral terminal lengths of the ceramic grids. Tubular springs are disposed between the pressure plates and a rigid external support. The tubular springs have their axes vertically disposed to facilitate passage of coolant gas through the springs and are spaced apart a selected distance such that at some preselected point of spring deflection, the sides of the springs will contact adjacent springs thereby causing a large increase in resistance to further spring deflection. (AEC)

**33301** FASTENER FOR AN ASSEMBLY OF PLATES. Edward F. Groh (to U. S. Atomic Energy Commission). U. S. Patent 3,101,309. Aug. 20, 1963.

A fastener is provided for a spaced-apart parallel plate fuel assembly. The fastener, attached by screws to a key that passes through the edges of the assembled plate, serves as a retainer for the outermost plate as well as a bidirectional spacer for separating the fuel assembly from two neighboring fuel assemblies. (AEC)

## Power Reactors

**33302** (AGN-TM-403) ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. ML-1 REACTOR STABILITY TESTS. D. H. Crimmins and H. J. Snyder (Aerojet-General Nucleonics, San Ramon, Calif.). June 1963. Contract AT (10-1)-880. 48p.

Analog computer studies indicated that the reactivity coefficients of the ML-1 are too small to cause instabilities during reactor operation. Digital computer analysis of the noise levels in the reactor flux records from the initial operation of the ML-1 revealed no indications of unstable tendencies, although an error analysis qualified the results. The Milletron spectral analysis computer was used to monitor ML-1 reactor stability during a full power run, including startup, shutdown, and several power level changes. Analysis of the Milletron data led to the conclusion that there were no unstable tendencies in the reactor power range observed and that stable operation could be expected at considerably higher powers. The major source of neutron flux noise was attributed to the moderator system and was associated, with a reasonable probability, with random variations in temperature and/or voids in the moderator. (auth)

**33303** (CEND-139) PL CONDENSER EVALUATION REPORT. V. R. Mardoc and R. G. Young (Combustion Engineering, Inc. Nuclear Div., Windsor, Conn.). June 26, 1961. Contract AT(10-1)-967. (IDO-19031)

The air-cooled steam condenser and sub-cooler developed for use with the PL series of natural circulation boiling water nuclear power plants are designed to condense 13,000 lb/hr at 10% moisture at 15 in. Hg and to subcool the condensate to 100°F at an ambient temperature of 60°F. The design heat load at this temperature is $12.63 \times 10^6$ Btu/hr. Performance test results showing that these design requirements are met are presented. The air flow system maintained inlet air temperature at 60°F even in subfreezing atmospheres by blending hot and cold air when necessary. (D.C.W.)

**33304** (CONF-39-33) REPORT OF THE OBJECTIVES AND PLANS FOR THE AEC'S CIVILIAN POWER GAS COOLED REACTOR PROGRAM. Robert E. Pahler (Division of Reactor Development, AEC). June 1963. 16p.

From American Nuclear Society Meeting, Salt Lake City, June 1963.

Progress in the U. S. civilian power gas-cooled reactor program is discussed. Gas reactors having technical features of high conversion ratio, high temperature, high fuel burnup, and capability of construction in large sizes make them very attractive as potential producers of economic power in the very near term. The operation of Peach Bottom-HTGR and EGCR in late 1964 and 1965, respectively, will contribute to the successful exploitation of thermal gas-cooled reactors. Since the graphite fuel concept promises very low fuel cycle costs along with reactor coolant conditions that can exceed current practice, it was concluded that the concept provides a long term potential that promises some very exciting possibilities. (auth)

**33305** (CONF-39-49) THE ORNL GCR-3, A 750 Mw(e) GAS-COOLED CLAD-FUEL REACTOR POWER PLANT. M. Bender and W. R. Gall (Oak Ridge National Lab., Tenn.). [nd]. Contract W-7405-eng-26. 44p.

From American Nuclear Society Meeting, Salt Lake City, Utah, June 1963.

An advanced, gas-cooled, clad-fuel reactor power plant to generate 750 Mw of electricity was designed as a study of the potential capability of that system. The graphite-moderated reactor generates 1908 Mw of heat in 1062 fuel channels 21 ft long for a power density of 5.5 kw/liter. Gas temperatures entering and leaving the reactor are 574 and 1150°F, respectively, operating at 420 psia. Steam at 2415 psia and 950°F with reheat to 1000°F drives a 763-Mw(e) turbogenerator and also four 31,000-hp blower drive turbines and the boiler feed pumps. Net thermal efficiency of the plant is 39.4%. Estimated direct cost of construction is $110,267,000, or $147 per kilowatt net electric output. Fuel-cycle costs at 20,000 Mwd per metric ton of uranium are 1.46 mills/kwhr, operating and maintenance costs are 0.39 mill, and fixed charges range from 1.80 to 4.52 mills, depending on method of financing. Total power generation costs at an 80% load factor range from 3.65 to 6.50 mills/kwhr. (auth)

**33306** (DLCS-3050123) RADIATION SURVEY OF THE REACTOR VESSEL HEAD. CORE 1, SEED 3. Test Evaluation. (Duquesne Light Co., Shippingport, Penna.). First Issue, Feb. 28, 1963. Contract AT(11-1)-292. 24p.

A detailed radiation survey of the Shippingport Reactor vessel head was made, and the magnitude of the radiation in the vicinity of the vessel head after extended power operation and the effect of normal rod motion and scrams on this magnitude are reported. (L.T.W.)

**33307** (EUR-281.e) REACTIVITY EFFECTS DUE TO VARIATIONS IN NUCLEAR PARAMETERS IN A THERMAL POWER REACTOR. G. Casini and M. Paillon (European Atomic Energy Community. Nuclear Research Center, Ispra, Italy). 1963. 21p. (EANDC(E)-45-L)

The influence on the neutron balance of small variations of some nuclear parameters in a natural-uranium power reactor was investigated. The most important nuclear cross section influences were found to be due to $U^{235}$ and $Pu^{239}$ fuel isotopes. In particular, a variation of 1% in the fission cross section of $Pu^{239}$ gave a variation of about 0.6% in the reactivity for an ORGEL-type reactor. As far as the lattice parameters are concerned, the calculations confirmed the necessity of improving the accuracy of the activation experiments, in particular for resonance escape probability determination, in order to have results comparable with criticality measurements. (auth)

**33308** (GA-4247) 40-MW(E) PROTOTYPE HIGH-TEMPERATURE GAS-COOLED REACTOR RESEARCH AND DEVELOPMENT PROGRAM. Quarterly Progress Report for the Period Ending December 31, 1962. (General Atomic Div., General Dynamics Corp., San Diego, Calif.). Contract AT(04-3)-314. 37p.

The more important developments in the HTGR program are summarized. Element III-B generated a total of 225 Mw-hr of fission heat, about 30% of the heat generated by a corresponding length of an average Peach Bottom element in three years at 80% load factor. A series of calculations was performed to evaluate the effect on core life of changes in the core design or in basic neutron cross sections. Other calculations were performed to investigate the magnitude of flux tilts resulting from misalignment of the shim rods during normal operations. It was found that the maximum flux tilt occurs when control is being shifted from one ring of rods to another, and that this tilt would result in increases of 4% in the peak power and 8% in the integrated power in the hottest fuel elements. A study was performed to determine the effect on maximum fuel temperature of nonhomogeneous fuel loadings. Tests of a porous filter of new design show that this filter is significantly less susceptible to plugging by graphite dust than the previous filter. Nuclear calculations indicated that from a

reactivity standpoint, molybdenum-sheathed thermocouples with a niobium coating would be superior to tantalum-sheathed thermocouples for fuel-element applications. A test was run to determine the compatibility of this type of thermocouple with graphite and impure helium. Testing of the prototype emergency-shutdown rod-drive mechanism continued. The mechanism satisfactorily performed ten cycles under battery power against the full 10,000-lb load resistance. The installation of the transfer machine in the test facility was completed and testing was initiated. The machine successfully removed and replaced dummy fuel elements in a full-size mockup of a core segment. The analysis of samples and data obtained during in-pile-loop operation continued. Release fractions of noble-gas isotopes calculated from gas samples continue to fall quite well on extrapolated curves of release-fraction versus fuel burnup based on previous data. Analyses of the graphite parts of element III-A indicate that these components contained only about 0.26% of the $Cs^{137}$ produced in the compacts. Studies of individual fuel particles from element III-A seem to indicate that almost all of the $Cs^{137}$ remains in the particles and that some of the $Ce^{144}$ is escaping. A study of the activities found on the second set of plateout sleeves during III-B operation suggests the possibility of barium and cesium vapor deposition. A detailed calculation of the emergency-cooling accident was completed. In addition to the determination of reactor vessel and core temperatures as a function of time, the release of isotopes of biological significance and the resulting offsite doses were determined, and the reactivity effect of the release of core poisons was calculated. (auth)

**33309** (GEAP-4200) EVESR—NUCLEAR SUPERHEAT FUEL DEVELOPMENT PROJECT. Third Quarterly Report, December 1962–February 1963. R. T. Pennington (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). Mar. 1, 1963. Contract AT(04-3)-189. 66p.

The schedule for initial loading of fuel in the EVESR reactor is changed to the latter part of May 1963. This change is due to the addition of the R&D instrumentation and coolant chemistry systems to the reactor system. Design of the Mark II EVESR fuel was completed, and fabrication of this fuel was initiated. Work is progressing on schedule in the planning activity, completion of engineering for the R&D coolant chemistry system, the R&D instrument system, the initial core loading and physics measurement program, and the fuel performance data handling procedures. In this regard significant progress was made in the incorporation of a data retrieval system which will provide for orderly accumulation of fuel fabrication information, fuel design variables, fuel performance data, and postirradiation inspection. Initial scoping activity in the advanced fuel program has indicated possible performance limitations for advanced fuel. (N.W.R.)

**33310** (GEAP-4277) EVESR-NUCLEAR SUPERHEAT FUEL DEVELOPMENT PROJECT FOURTH QUARTERLY REPORT, MARCH–MAY 1963. (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). June 1963. Contract AT(04-3)-189. 59p.

Construction of the EVESR reactor and plant is 99% complete. Installation of the fuel evaluation instrumentation and coolant sampling system is 70% complete. Design work was initiated on specialized instrumentation to obtain the additional data that will be required to evaluate the developmental superheat fuel. Fabrication of the fuel bundles is scheduled to be completed in July. Coupon samples of superheat fuel clad materials were prepared for irradiation in the EVESR core. Control samples will be exposed to superheated steam outside the core. The physics prestartup report which outlines the EVESR critical tests to be performed and the expected results was completed. Considerable progress was made toward completing the computer codes to be used for storing, processing, and reducing the vast quantities of fuel fabrication and performance data that will result from the EVESR superheat fuel development program. Pre-irradiation measurements of the fuel are being made. Preliminary plans were made for the advanced fuel bundles. (auth)

**33311** (GEAP-4306) DEVELOPMENT PROGRAM FOR INCREASED OUTPUT IN THE GARIGLIANO NUCLEAR REACTOR. Quarterly Report No. 3. T. Sorlie (General Electric Co. Atomic Power Equipment Dept., San Jose, Calif.). July 1, 1963. Work Performed under United States–Euratom Joint Research and Development Program. Contract AT(04-3)-189. 25p. (EURAEC-752)

The encapsulated material test specimens and the capsule baskets were received at the SENN site. All specimen capsules were mounted in the baskets, and the baskets installed in predetermined locations inside the reactor vessel and steam drum. The installation of computer cable and instrumentation was completed in all critical areas. Computer input-output functions and computational functions were completed and flow-charted in the areas of plant performance and core performance. In the area of physics the specification of the core power distribution module is being completed at the present time. The specified method solves the critical wave equation in three dimensions utilizing essentially a one-energy neutron group and a very coarse geometry. Standard methods of iterating steam void and power distribution are employed in arriving at a converged solution in both power distribution and steam voids. In preliminary calculations the method was producing excellent agreement with standard few-group two-dimensional calculations using PDQ-4. (auth)

**33312** (GEMP-215) 630A MARITIME NUCLEAR STEAM GENERATOR. Progress Report No. 5. (General Electric Co. Advanced Technology Services, Cincinnati). June 28, 1963. Contract AT(40-1)-2847. 149p.

The current status of the 630A Nuclear Steam Generator program is given in a summary of design features, safety assessments, and development work. Thermodynamic studies of the 85-cell 630A indicate that a 63,000 SHP capability can be achieved by using steam as the primary coolant; weight, size, and capital cost would be essentially the same as for the 30,000 SHP air-cooled unit. A lightweight air-cooled 50,000 SHP unit was investigated. The weight of this assembly was estimated to be 446 tons. The power rating of this unit could be increased to 100,000 SHP with steam cooling. Measurements in the critical experiment show that, with a minor redistribution of moderator volume fraction and fuel, the desired gross radial power can be achieved. The two-tube boiler test rig was operated and steam design conditions of 850 psia and 950°F were obtained. Stability between tubes was demonstrated in steady state and transient conditions and the feedwater control demonstrated the capability of controlling the steam superheat temperature under steady state and transient conditions. Fabrication of the blower seal test was begun. The ORF-4 fuel burnup sample was placed on test and has accumulated over 200 test hours. The ORF-3 fuel burnup test completed the equivalent of over 20,000 hours of 630A operation. The MTR 3-F-2 fuel burnup sample was removed from test after about 5000 hours at equivalent 630A operation. Laboratory stress and oxidation tests on

fuel samples have exceeded 10,000 hours at temperatures above those expected in the 630A without excessive creep and apparently without excessive oxidation. (N.W.R.)

**33313** (IDO-28584(Add.1)) ARMY GAS-COOLED REACTOR SYSTEMS PROGRAM. STUDY OF MOBILE GAS-COOLED NUCLEAR POWER PLANTS. (Aerojet-General Nucleonics, San Ramon, Calif.). July 1963. Contract AT(10-1)-880. 42p.

The results of a study to evaluate the feasibility of the use of an unmoderated, europium-poisoned reactor in a mobile gas-cooled nuclear power plant are presented. A comparison was made between the characteristics of such a reactor and those of the HDMR (High Density Moderated Reactor). It was concluded that although the concept under study has attractive thermodynamic characteristics (which can be utilized to provide a margin of design flexibility) in the overall evaluation, this concept is not superior to the HDMR. (auth)

**33314** (LAMS-2933) QUARTERLY STATUS REPORT ON ULTRA HIGH TEMPERATURE REACTOR EXPERIMENT (UHTREX) FOR PERIOD ENDING JUNE 20, 1963. (Los Alamos Scientific Lab., N. Mex.). July 1963. Contract W-7405-eng-36. 20p.

Construction progress on the Ultra High Temperature Reactor Experiment (UHTREX) facility is reported. Progress is also reported on core temperature and stress analysis, fuel-transfer gas lock developments, shutdown rod development, fuel element transfer, component testing, thermal conductivity of Solami laminated foil, core flow model development, core combustion simulation, gas cleanup system development, control system development, blower development, transfer function calculations, steady-state parameter studies, and fuel element preparation and processing. (N.W.R.)

**33315** (NP-12999) ELK RIVER REACTOR TECHNICAL SPECIFICATIONS. (Rural Cooperative Power Assn., Elk River, Minn.). July 1, 1963. 89p.

The technical specifications that govern the design and operation of the Elk River Reactor plant are presented. Design specifications of physical features of the facility and limitations governing operations of the facility to be observed by operating personnel are included. Topics covered include: site, containment, primary coolant system, primary coolant auxiliary systems, secondary coolant system, reactor core, control and safety systems, radiation monitoring systems, waste disposal systems, ventilation system, emergency cooling and decay heat removal systems, fuel storage, and administrative and procedural safeguards. (M.C.G.)

**33316** (ORNL-3445) GAS-COOLED REACTOR PROGRAM SEMIANNUAL PROGRESS REPORT FOR PERIOD ENDING MARCH 31, 1963. (Oak Ridge National Lab., Tenn.). July 23, 1963. Contract W-7405-eng-26. 378p.

Progress is reported on the development of gas-cooled reactors. The report contains eleven sections which are abstracted separately in NSA. These sections are contained in two parts: investigations in support of the Experimental Gas-Cooled Reactor and advanced reactor design and development. The four sections abstracted under Part I are: performance analyses, component development and testing, materials development, and irradiation testing of components and materials. The remaining sections are under Part II and they are: development of fueled-graphite bodies, investigations of fueled-graphite systems, clad fuel development, investigations of moderator materials, studies of advanced systems, experimental investigations of heat transfer and fluid flow, and facilities and equipment. (N.W.R.)

**33317** (ORNL-3445(p.3-29)) PERFORMANCE ANALYSES. (Oak Ridge National Lab., Tenn.).

Efforts to correlate data based on the Hanford exposure unit for the exposure and shrinkage or growth of graphite with an appropriate flux unit to make the dimensional changes independent of the reactor type resulted in a change of the conversion factor. A lower threshold was found to be more reasonable, and the resulting exposures were 40% lower than calculated previously for the 20-yr design life of the EGCR. The predicted fission-product activity release from the EGCR fuel pellets was recalculated based on data from low-burnup irradiation tests of prototype EGCR fuel elements with thermocouples for central $UO_2$ measurements. The peak central $UO_2$ temperature was found to be only 2390°F, the apparent diffusion coefficient was much less than originally assumed, and the fission-product-release rate was a factor of 200 less than previously predicted. The predicted equilibrium total activity release based on the test data is 380 curies. The EGCR coolant system shielding is designed for 1,000 curies of fission products with an effective gamma energy of 1 Mev per disintegration. The temperature distribution to be expected in the graphite surveillance specimens in the EGCR was calculated. The number of fuel element failures that would result from the maximum credible accident was recalculated to be much less than 751. The EGCR graphite oxidation code was used for the calculation of hydrogen generation rates in accidents involving an internal rupture of a steam generator. The conditions necessary to prevent hydrogen flammability in the event of an accident were established. Experiments were conducted to determine the source-neutron multiplication of EGCR fuel assemblies under conditions which might exist in transportation and storage. (N.W.R.)

**33318** (ORNL-3445(p.30-6)) COMPONENT DEVELOPMENT AND TESTING. (Oak Ridge National Lab., Tenn.).

Flow tests were continued with the fuel channel top and bottom dummy assembly. An adjustable orifice for the bottom dummy was developed that provides the flow control needed. Venturis for EGCR instrumented channels were tested. Fabrication work on the instrumented fuel assemblies for the first core loading of the EGCR continued. The facility for testing the EGCR prototype control-rod drive was completed and placed in standby condition. Work continued on the fabrication of the main coolant blowers and the pressure-vessel cooling-system compressors. The three bottom in-pile loop tees and the tee for the emergency cooling loop are being installed. Stainless steel baked at 500°C in helium containing fission products was successfully decontaminated with hot oxalic acid solutions containing fluoride and hydrogen peroxide and with steam spray techniques. Carbon steel similarly contaminated was decontaminated by blasting with a steam jet into which an oxalate-citrate-peroxide solution was aspirated. (N.W.R.)

**33319** (ORNL-3445(p.37-62)) MATERIALS DEVELOPMENT. A. Goldman (Oak Ridge National Lab., Tenn.).

Several standard ORR poolside irradiation capsules containing EGCR production-quality $UO_2$ pellets were fabricated for testing in the ORR poolside facility, and a roughened surface fuel element designed to operate at an estimated power output of 65,000 Btu/hr·ft was fabricated for irradiation in ORR loop No. 1. Components for 20 instrumented EGCR fuel assemblies are being fabricated. The oxidation behavior of nitrided type 304 stainless steel

under EGCR operating conditions was determined to be a direct function of the thickness of the oxide layer in experiments run to examine the properties of the nitrided surface layer being applied to the nozzles of the pneumatic temperature measurement system of the EGCR. A surveillance testing program for monitoring changes in EGCR moderator graphite was planned. Postirradiation examination of EGCR fuel bushings indicated a tendency toward chipping and cracking at the edges formed by the end faces and outer cylindrical surfaces. Severe out-of-pile quench tests indicated deterioration along the outer cylindrical edges which progressed with the number of quench cycles. Light sanding of the end faces produced the desired lands and reduced the tendency of the bushings to chip. Radiographic and phase-sensitive eddy-current techniques were found to be effective in detecting voids, cracks, and laminations in extruded graphite cylinders. (N.W.R.)

**33320** (ORNL-3445(p.63-108)) IRRADIATION TESTING OF COMPONENTS AND MATERIALS. D. B. Trauger and O. Sisman (Oak Ridge National Lab., Tenn.).

Eight instrumented fuel elements were operated in GCR-ORR loop No. 1 in the power range 21,000 to 42,000 Btu/hr·ft. It appears that leaking, ruptured, or ventilated elements may constitute a much smaller problem than supposed earlier. Fuel elements with roughened surfaces are shown to have improved heat transfer. Examinations were made of capsules 02-5, 04-5, 05-5, 07-5, and E-4. Fission-gas-release studies were continued with thin-slab specimens of single-crystal $UO_2$. Work continued on the preparation of specimens for the EGCR pressure-vessel surveillance program. Metallographic examinations revealed the same fracture mode for irradiated and unirradiated specimens for the same fracture energy. (N.W.R.)

**33321** (ORNL-3445(p.111-37)) DEVELOPMENT OF FUELED-GRAPHITE BODIES. A. Goldman (Oak Ridge National Lab., Tenn.).

Comparison of crushing strength with in-pile performance has shown a direct relation between the number of cracked coated particles found after irradiation and the minimum crushing strength measured for samples from the same lot of particles. Monolayers of coated particles were crushed under loads of 2500 to 20,000 lb and then acid leached to remove the exposed uranium. Tests were conducted for determining fuel migration in coated fuel particles held at 1000 to 2000°C for periods up to 1000 hr. Pyrolytic-carbon coatings were prepared and evaluated. Two neutron-activation tests were made to obtain quantitative information on the release, transport, and deposition of iodine-131, barium-140, strontium-89, and tellurium-132 from uncoated $UC_2$ particles. The release rates for xenon-133 in helium at 560 and 790°C were high in comparison with the rates for duplicate samples sintered in vacuum at the same temperature. The difference is attributed to partial oxidation of the $UC_2$ to $UO_2$. Experimental work is continuing on the fabrication of dense high-strength graphite bodies by molding and baking. Chlorine gas treatment of the spheres at 800 to 1000°C was found to be partially effective in removing exposed uranium. (N.W.R.)

**33322** (ORNL-3445(p.138-98)) INVESTIGATIONS OF FUELED-GRAPHITE SYSTEMS. O. Sisman, H. W. Savage, D. B. Trauger, and G. M. Watson (Oak Ridge National Lab., Tenn.).

The development and testing of pyrolytic-carbon-coated uranium carbide particles dispersed in graphite are summarized. The following topics are discussed: postirradiation examination of capsules, instantaneous fission gas release, capsule irradiations, fuel-ball irradiation tests, fission product transport and deposition in coolant circuits, decontamination of out-of-pile loops, characterization of gas-borne fission products, release of fission products by in-pile burning of irradiated fueled graphite, thorium diffusion in pyrolytic carbon, compatibility of pyrolytic-carbon-coated uranium carbide particles and uncoated fuel bodies with water vapor in helium, uranium migration in porous graphite, and decontamination of type 304 stainless steel from iodine-131 and tellurium-132 deposited from heated helium. (N.W.R.)

**33323** (ORNL-3445(p.199-217)) CLAD FUEL DEVELOPMENT. A. Goldman, O. Sisman, and D. B. Trauger (Oak Ridge National Lab., Tenn.).

Topics included are: irradiation effects on swaged and tamp-packed $UO_2-ThO_2$, high-temperature irradiation of $UO_2$ in LITR miniature capsules, rachetting of metal-clad fuel elements during thermal cycling, radiation effects on stress-rupture properties of chromium–nickel steel tubes, tensile properties of stainless steel after irradiation, wetting of beryllium with liquid metals, diffusion of carbon from ferritic steel to austenitic stainless steel, and thermal conductivity of $UO_2$ at 100 to 1300°C. (N.W.R.)

**33324** (ORNL-3445(p.218-50)) INVESTIGATIONS OF MODERATOR MATERIALS. A. Goldman, B. L. Greenstreet, G. M. Watson, and H. W. Savage (Oak Ridge National Lab., Tenn.).

The development and properties of graphite and beryllium oxide as reactor moderator materials are described. Topics covered include: mechanical properties and in-pile creep of graphite, graphite-stainless steel compatibility studies, transport of gases through graphite, graphite reactions in helium containing carbon dioxide, geometry studies of irradiation-induced changes in graphite, design criteria for graphite components, compatibility of graphite and metals in hydrogen, behavior of beryllium oxide compacts under fast neutron irradiation, and metallographic examination of cladding and end caps from beryllium oxide experiment. (N.W.R.)

**33325** (ORNL-3445(p.251-97)) STUDIES OF ADVANCED SYSTEMS. (Oak Ridge National Lab., Tenn.).

Development of gas-cooled reactor systems are discussed. Topics included are: GCR-3 and -4 power cycle studies, comparison of coolants for gas-cooled reactors, parametric study of large pebble-bed reactors, fuel-cycle cost study for a large pebble-bed reactor, AVR fuel management procedures, analyses of nozzle-to-shell attachments, neutron captures in second- and higher-generation fission-product poisons, and fast-neutron flux monitor developments. (N.W.R.)

**33326** (ORNL-3445(p.298-328)) EXPERIMENTAL INVESTIGATIONS OF HEAT TRANSFER AND FLUID FLOW. H. W. Hoffman and G. Samuels (Oak Ridge National Lab., Tenn.).

The constants in the equation correlating the heat transfer in a 7-rod cluster geometry with the flow and the axial position were redetermined using all available data. The pressure-loss coefficients associated with rough surfaces were determined in two long-rod clusters of somewhat different geometries. The assembly of the apparatus and installation and check-out of instrumentation for the study of heat transfer from rough surfaces was continued. An experimental facility was placed in operation for studying the friction factor and heat transfer coefficient of air in an annulus with a roughened inner surface and a smooth outer surface. The problem of hot spots in a gas-cooled bed of fueled spheres was studied. The study of the static and dynamic characteristics of a random bed of $1\frac{1}{2}$-in.-dia.

graphite spheres within a full-scale model of the pebble-bed core was continued. Friction factors were calculated from data obtained for the pressure distribution in the various beds. Bed levitation phenomena were studied by observing the behavior of the spheres on the top face of the bed, while the air flow was slowly increased and decreased at a velocity near that required to levitate the full bed. The gas velocity distribution at the exit face of the bed was determined by traverse with a hot-wire probe. Development of an apparatus and technique for studying mass transfer from benzoic acid spheres within and in closely packed sphere clusters was continued. (N.W.R.)

**33327** (ORNL-3445(p.329-46)) FACILITIES AND EQUIPMENT. (Oak Ridge National Lab., Tenn.).

Installation of the in-pile section and the first experimental assembly was completed, and operation of GCR-ORR loop No. 2 was initiated. The experimental assembly is a low-power unit for determining the neutron flux by the argon-activation technique. Work continued on the development of gas-bearing compressors. The regenerative grease-lubricated compressor in GCR-ORR loop No. 1 continued to operate satisfactorily. Development work was completed on the Greenbrier process chromatograph, which was adapted for analysis of radioactive helium samples from GCR-ORR loop No. 2. In measurements at the 100-ppm concentration level, the reproducibility is better than 5 ppm for all components except hydrogen and better than 40 ppm for hydrogen. Thermocouple materials are being tested out-of-pile under environmental conditions approaching those conceived for a pebble-bed reactor. Twenty-five types of wires are being exposed to graphite and helium containing 500 ppm $H_2$ and 500 ppm CO at 1400 and 1800°F. Of the nine wires checked after a 36-day exposure, only Chromel-A and type 347 stainless steel showed significant error at the lower temperature. At 1800°F, all wires were in error except one with the composition 50% Mo-50% Re. Metallographic samples were taken from sheathed Chromel-P-vs Alumel couples exposed to various atmospheres (CO, He, $H_2$). Emf peaks in the error curve occurred at the same geometrical location as the maximum oxidation on the wires. The spiral graphite furnace used to test tungsten–rhenium couples in helium–CO atmospheres was improved by doubling the length of the heating section of the helix and thus producing a flat temperature zone for the calibration of thermocouples. (auth)

**33328** (TID-19066) TECHNICAL QUALIFICATIONS FOR NUCLEAR PLANT OPERATION. (Rural Cooperative Power Assn., Elk River, Minn.). July 1, 1963. Contract AT(11-1)-651. 36p.

Organization and responsibilities in the operation of a nuclear power plant are discussed. Training and participation in the startup of the Elk River Reactor are described. The education and experience résumés for personnel in charge of management of operations and radiological physics activities at the Elk River Nuclear Power Plant are presented. (M.C.G.)

**33329** DETERMINATION OF OPTIMUM TEMPERATURE FOR THE REGENERATIVE PREHEATING OF FEED WATER IN COMBINED NUCLEAR POWER PLANTS. C. Haiduc. Acad. Rep. Populare Romine, Studii Cercetari Energet., Ser. B, 13: 179-95(1963). (In Rumanian)

The analytical method is given for the computation of the optimum temperature for the regenerative preheating of feed water in combined nuclear power plants. The method may be applied also to other types of nuclear power plants. (auth)

**33330** HIGH PERFORMANCE EXPECTED FROM PEACH BOTTOM, PA. Atomics, 16: No. 4, 45-50(July-Aug. 1963).

The performance capabilities of Peach Bottom Power Reactor are presented. The high-temperature operation, gas coolant, graphite moderator and reflector, $U^{235}$–Th fuel cycle, design, fuel elements, control rods and drives, and the primary coolant system are also discussed. (C.E.S.)

**33331** CANDU TO UNDERSELL COAL BY 1 MILL IN '70s. L. R. Haywood (Atomic Energy of Canada Ltd., Toronto). Can. Nucl. Technol., 2: No. 3, 37-9(1963).

The probable future development of $D_2O$-moderated nuclear power plants in the middle 1970s is discussed, and the capital and operating costs of the plants are forecasted. Bulk boiling at the outlet of fuel channels will increase the efficiency, and other possible ways for cost reduction and improvement in a 450-Mw(e) $D_2O$ plant are considered. It is concluded that nuclear power will cost 4.84 mills/kwh compared to 5.80 mills/kwh for coal-fired units, by 1973. (D.L.C.)

**33332** AN 1800 Mwe NUCLEAR PLANT: DESIGN AND COST. N. L. Williams (Canadian General Electric Co., Ltd., Toronto). Can. Nucl. Technol., 2: No. 3, 40-4(1963).

A proposed nuclear power plant designated as HWR-1800 is described which comprises four 475-Mw(e) heavy-water reactor units. A detailed analysis is presented of the construction, fuel, and operation and maintenance costs. It is concluded that the plant can produce power for as little as 3.3 mills/kwh. (D.L.C.)

**33333** FORGED FUEL CHAMBERS FOR CANADIAN NUCLEAR POWER. Drop Forging Topics, 23: No. 3, 8p. (1962).

The production of fuel chambers with high yield strength and corrosion resistance for nuclear power applications by die forging of AM-355 stainless steel and subsequent machining is reported. (Rev. Metal Lit., 19: No. 11, Nov. 1962)

**33334** COMPETITIVITY. M. Silvestri and S. Villani (Laboratori CISE, Milan). Energia Nucl. (Milan), 10: 336-9(June 1963). (In Italian)

A description is given of the present economic situation of nuclear power plants. Capital and fuel costs as well as their future trends are also commented on. Some factors are indicated which may contribute in a further reduction of costs. (auth)

**33335** SHIP REACTORS AT PRESENT AND IN THE FUTURE. Joergen Elming. Ingenioeren, 72: 173-8(Mar. 1963). (In Danish)

A brief review is given of the characteristics of the ship reactors in operation. Then the characteristics of the planned Danish Alpha II and the American Consolidated Nuclear Steam Generator are compared with the Savannah Reactor. Cost comparisons of the planned reactors are also included. (J.S.R.)

**33336** THE PRESENT STATE OF NUCLEAR SUPERHEATING. I. Casagrande and G. Mazzotti (Laboratori CISE, Milan). Riv. Ing. Nucl., 1: 21-37(Jan.-Feb. 1963). (In Italian)

A brief review is given of the research programs on the development of reactors generating superheated steam. The characteristics of nuclear superheating are first summarized. In conclusion, the characteristics of five superheating reactors—Beloyarsk, Pathfinder, Bonus, Borax V, and BHWR—are tabulated. (J.S.R.)

**33337** INITIAL OPERATING EXPERIENCE WITH THE NPD REACTOR. L. G. McConnell (Hydro-Electric Power Commission of Ontario, Toronto). 17p. (CONF-69-4)

From Conference on Operating Experience with Power Reactors, Vienna, June 1963.

Canada's first nuclear power station, the Nuclear Power Demonstration station, reached full power on June 28, 1962. Although designed for base-load operation it will, during the early stages, be operated part of the time on high-capacity runs and part of the time on improvement periods. Progress has been favorable so far; the first high-capacity run of six weeks' duration yielded a capacity factor of 70%. Improvements already made have increased safety, improved performance, and demonstrated potential methods of capital cost reduction for future stations. For example, shaft seals on primary coolant pumps have been modified for better performance; freezer-type vapor recovery equipment has been replaced in favor of absorption columns to reduce heavy water vapor loss; and flow limiters are being installed in sample lines to reduce losses of heavy water in the event of joint failures. Heavy water loss rates have been reduced from 15 kg per day to 5.5 kg per day. During December 1962, two simultaneous leaks from the on-power refuelling machine led to an unusual sequence of events in which a considerable amount of hot high-pressure heavy water was spilled into the reactor vault where it suffered a slight downgrading in isotopic purity. It was upgraded and the reactor returned to operation by the end of the month. All safety devices operated correctly during the incident as did the provisions for containment of heavy water. (auth)

**33338** THE FIRST TWO YEARS OF OPERATING EXPERIENCE OF KAHL NUCLEAR POWER STATION. A. Weckesser (Versuchsatomkraftwerk Kahl GmbH, Kahl, Ger.) and H. J. Bruechner. 30p. (CONF-69-2)

From Conference on Operating Experience with Power Reactors, Vienna, June 1963.

Kahl, the first European private atomic power station, has been operating at load since June 1961. Kahl is equipped with a boiling water reactor, operating in an indirect cycle and with natural circulation. Its electrical net capacity is 15 Mw, and the power produced until February 1963 amounts to 140 million kwh. In the paper the operating experience, particularly the extensive testing program such as concerning transient behavior and gamma scanning, is reviewed. Results on the operating performance of certain plant components such as control rod drive system, off-gas system, and turbine are presented. After this testing program the plant has been operated at base load for some time in order to obtain realistic experience on fuel performance. After completion of the base load phase of operation a nuclear superheating test loop will be installed and run in the Kahl reactor. (auth)

**33339** THE PERFORMANCES OF MAJOR PLANT ITEMS AT CALDER HALL. E. L. Desbruslais (United Kingdom Atomic Energy Authority, Sellafield, Cumb., Eng.). 47p. (CONF-69-6)

From Conference on Operating Experience with Power Reactors, Vienna, June 1963.

For over six years Calder Hall has been operated as a base-load power station and has sustained faults similar to those experienced by conventional power plants. All the faults have occurred in the conventional plant and none in the nuclear reactors themselves. Experience has demonstrated that from a reactor safety viewpoint, reactors and major plant items, together with the Grid connections, must be treated as a whole. No significant changes have been detected which suggest that the reactor pressure vessel or the graphite moderator will limit plant life. Asymmetric temperature distribution exists round the outlet gas ducts and now limits reactor power. The initial fitting of more thermocouples, strain gages, and provision for visual examination at high stress and temperature areas is recommended. The humidriers are no longer used during normal operation and consequently a small increase in reactor power has resulted. Recommendations are made for the frequency of surveys of heat exchangers, main gas ducts, and bellow units. A small increase in steam generation has resulted from reducing gas bypassing. Only minor difficulties have been experienced with the centrifugal type of gas circulators. A small loss in production occurred initially because of commutator flashovers on the highly stressed blower drive motors and generators. The provision of duplicate standby auxiliaries, together with the interconnection of steam and water systems, has been amply justified. The B.C.D.G. equipment has proved extremely satisfactory. Because the channel group sensitivity is higher than necessary, modifications to achieve shorter cycle times at the expense of some sensitivity are being contemplated. The re-arrangement made to the power supplies for reactor instrumentation and safety circuits is discussed. The grading of alarms and sequence of importance and a "first up" feature are recommended. The two guard line system has proved adequate and the need for three or more is questioned. Statistics have shown that the data logging equipment is extremely reliable. More standardization of fuel handling equipment is advocated. The use of special flasks and special discharge equipment is time-wasting and should be discouraged. Modifications made to the charge/discharge machines and auxiliary plant are described. Careful handling of fuel during loading is emphasized. Fuel channel television cameras and special grabs have enabled discharge times to be reduced. Only minor faults have been experienced with the complex control rod mechanisms and associated control equipment. As far as possible plant controls should be centralized and important control centers and items of plant should be protected from accidental damage from external sources. Automatic start-up and paralleling features for the emergency diesel plant are considered unnecessary but the plant could, with advantage, be centralized. (auth)

**33340** INFORMATION ON DESIGN AND OPERATING EXPERIENCE WITH POWER REACTORS IN MEMBER STATES. M. Khan (IAEA, Vienna). 8p. (CONF-69-1).

From Conference on Operating Experience with Power Reactors, Vienna, June 1963.

As part of the Agency's nuclear power program and in response to the offers made by several countries, the Agency has been following closely the development of eight power reactor projects in the United States, two in Canada and one in the United Kingdom. Information collected on the experience in design construction and operation of these plants is published annually. In the future, with the co-operation of more member states, the Agency plans to extend this program and issue periodic reports summarizing similar experience with more nuclear plants and thereby provide wider dissemination of this much needed information. (auth)

**33341** INITIAL OPERATIONAL RESULTS OF THE FIRST BELGIAN NUCLEAR POWER STATION BR3. M. Potemans and M. Gueben (CEN, Mol, Belg.). 41p. (CONF-69-5)

From Conference on Operating Experience with Power Reactors, Vienna, June 1963.

The BR3 Nuclear Power Plant, property of the Centre d'Etude de l'Energie Nucléaire (C.E.N.), is located at Mol-Donk on the site of the latter, and at a distance of 40 miles as the crow flies from Brussels. The operation of the plant is done by an Industrial Group. The reactor went critical, for the first time, on August 29, 1962. Results are presented of the preliminary tests and of the first months of operation. The reactor BR3 is of the pressurized, light water moderated and cooled type, with a nominal thermal power of 40.9 Mw. The core is heterogeneous, using $UO_2$ fuel, clad with stainless steel, and has two regions. The outer region is enriched to 4.43% by weight, the inner one to 3.7%. Main coolant pressure is 140 kg/cm$^2$. Different "primary" circuits are in connection with the reactor. The steam generator has a nominal capacity of 70 T/h. The turbine has two stages and three extraction lines and a nominal power of 11,700 kw. The personnel were selected from the experienced personnel of the conventional power plants. They got a thorough training in the nuclear field as well as in the classical. Results are given of the practical determination of the plant characteristics: control rod worth and boron worth determination, calibration of the control rods, temperature and pressure coefficients determination, determination of the dropping time of the control rods, etc. The excess reactivity was calculated for the clean core. These tests were done at zero power and after 441 EFPH (burn-up: 750 Mwj). A résumé is given of the load transient tests and the power coefficient determination. Different problems encountered during operation are treated: (1) Radiation activity in the plant: it is concluded that the habitual work in the normal areas is not affected by the radiation intensities present. (2) Activity in the air of the building: the only problem which appeared until now is the presence of radon in the reactor building and in certain auxiliary buildings. This radon comes from the concrete. (3) Leak rate of primary water: about 100 l/hr. (4) Mechanical difficulties, e.g., with the charging pumps, untightness of valves, etc. (auth)

**33342** OPERATING EXPERIENCE WITH INDIAN POINT NUCLEAR ELECTRIC GENERATING STATION. W. C. Beattie and R. H. Freyburg (Indian Point Nuclear Station and Consolidated Edison Co. of New York, Inc., Buchanan, N. Y.). 26p. (CONF-69-8)

From Conference on Operating Experience with Power Reactors, Vienna, June 1963.

Indian Point Station Unit No. 1 consists of a 585-Mw(t) pressurized water reactor, four primary coolant loops with horizontal heat exchanger boilers, two 1,100,000-lb/hr oil-fired superheaters, and a 275,000-kilowatt turbine generator. The reactor fuel is a mixture of fully enriched $U^{235}$ oxide and $Th^{232}$ oxide. The station is located on the Hudson River about 24 miles north of New York City. Because of this proximity to New York, exceptional safeguards against the occurrence of a reactivity excursion as well as against the radiation effects of such an excursion were incorporated into the station design. Construction was completed in May 1962. Fuel loading was accomplished in June and the reactor was taken critical for the first time on August 2, 1962. Low power testing up to 5 Mw(t) at ambient and at elevated temperatures was done during August, and the turbine generator was first phased into the Consolidated Edison system on September 16, 1962. Testing at reactor power levels up to 50% extended into November and was marked by frequent automatic shutdowns, a large number of which were initiated in the conventional plant. Control rod drive control system difficulties were the heaviest contributor from the nuclear plant to automatic rod insertion operations and to delays in recovery from automatic trips. On November 14, 1962, the station was shut down for scheduled piping changes in the conventional plant and for modifications and additions to the control rod drive system. The latter included the installation of a dry nitrogen purging system for the control rod drive housings designed to minimize the effects of seal water leakage into the rod drive housings. This appears to have been the major cause of the false indications encountered with the reactor control system. The unit was returned to service on January 1, 1963. Testing at reactor power levels up to 100% under steady load conditions was completed on January 27, 1963. Test results have followed closely the predicted performance for the reactor. Further testing of response to load transients is to continue into the Spring of 1963. (auth)

**33343** THE TECHNICAL TRAINING PROGRAM FOR NUCLEAR POWER STATION PERSONNEL. G. R. Howey (Hydro-Electric Power Commission of Ontario, Toronto). 18p. (CONF-69-3)

From Conference on Operating Experience with Power Reactors, Vienna, June 1963.

Canada's Nuclear Power Demonstration station (NPD), initiated by the federal agency Atomic Energy of Canada Limited, is operated and staffed by the Hydro-Electric Power Commission of Ontario, a provincial public utility. Obtaining and training staff for the station was made difficult by the fact that until recently most of Ontario's electricity requirements were supplied by the abundant hydroelectric resources of the province. Increasing use of thermal-electric energy since 1950 created an extreme shortage of staff experienced in the operating of thermal stations. To meet this situation, trained manpower for nuclear generating stations was developed by the following steps: 1. An initial group of professional engineers was selected from among persons with considerable experience in nuclear work, thermal stations, and electrical operation. 2. Another group of highly experienced operators and maintainers was selected. 3. The selected groups were given a rigorous training program involving operation of both nuclear and coal-fired stations, instruction from the designers of NPD, and training in the classroom and on the job. 4. A nuclear training center was established to select and train additional staff, conduct formal examinations, and be generally responsible for personnel quality standards. Independent examinations of personnel were conducted by the Atomic Energy Control Board, a separate federal regulatory agency. Five general categories of personnel are being developed: 1. Supervisors: professional engineers responsible for operating, maintenance, and administrative supervision; rotated periodically to increase their versatility. 2. Operators: four levels of qualification depending on the requirements of the job. 3. Control Maintainers: four levels of qualification; responsible for maintenance of all instruments, control equipment, and electrical equipment. 4. Mechanical Maintainers: various levels and combinations of skills (welding, machining, fitting, etc.); responsible for maintenance of all mechanical equipment. 5. Service Maintainers: responsible for a wide variety of less skilled tasks requiring lower qualifications. In addition to these general categories, a few specialists are required, such as chemists and radiation protection officers. Organization of the

NPD staff and training for future nuclear power needs are discussed. (auth)

**33344** THE FUTURE OF LARGE REACTORS. J. C. Rengel and W. L. Budge (Westinghouse Electric Corp., Pittsburgh). 21p. (CONF-15-3)

From American Power Conference Meeting, Chicago, Mar. 1963.

Economic and nuclear aspects of large power reactors are outlined, and prospects for future development of this type of reactor are discussed. (T.F.H.)

**33345** PHYSICS PERFORMANCE OF THE EBWR IN ITS ZERO TO 100 Mw OPERATION. H. P. Iskenderian. 19p. (CONF-39-4)

From American Nuclear Society Annual Meeting, Salt Lake City, June 1963.

The distribution of fuel elements in the EBWR core is described. Spike elements with boron steel strips were provided in the core for burnup allowance. A calibration of the control rod system with Zircaloy followers was made. Void coefficient measurements were made for two different $H_3BO_3$ concentrations. Power runs were made, and reactivity loss vs. power characteristic was obtained. Steam remaining in the core, or "carryunder," was indicated. Some of the spikes were removed for increasing the power to 80 Mw. Calculations were made of the reactivity loss with coolant void and of the average void vs. reactor power. (D.L.C.)

**33346** MEASUREMENTS MADE DURING THE COMMISSIONING OF THE WINDSCALE ADVANCED GAS-COOLED REACTOR (WAGR). R. R. Gallie (Reactor Development Labs., Windscale Works, Sellafield, Cumb., Eng.). 3p. (CONF-39-3)

From American Nuclear Society Annual Meeting, Salt Lake City, Utah, June 1963.

Some measurements were made on the WAGR fuel in the APEX and HERO facilities in order to derive the loading pattern. The reactor was then loaded, and measurements of the excess reactivity were in good agreement with predictions. Other measurements made were control rod calibrations, reactivity worths of control rods, isothermal temperature coefficient, and pressure drops. (D.L.C.)

**33347** THE HALDEN HEAVY WATER REACTOR—OPERATION WITH CORE I. K. P. Lien (Institutt for Atomenergi, Kjeller, Norway). 24p. (CONF-82-3)

From Canadian Nuclear Association Conference on Heavy Water Reactors, Ottawa, May 1962.

The Halden reactor plant and site are described briefly. The power operation and plant performance with Core I are described in some detail. The results of the research program on the characteristics of Core I are also given. (D.L.C.)

**33348** UTILITY SYSTEM CONDITIONS FAVORABLE TO EARLY INSTALLATION OF NUCLEAR POWER. R. K. Anderson (General Electric Co., San Jose, Calif.); J. J. Heagerty, W. D. Marsh, and W. N. Oberly. 27p. (CONF-15-8)

From American Power Conference, Chicago, Mar. 1963.

A treatment is presented of the economic application of nuclear power on today's electric utility systems. A utility system of 2000-Mw capacity is assumed. The capacity is expanded with the load, and the costs for each expansion are calculated. The process is then repeated for an alternate system of 4000-Mw initial capacity. The nuclear cost factors are discussed in detail. It is concluded that nuclear savings occur for fossil fuel costs above 25¢ per million Btu, nuclear power is economic in larger unit sizes, nuclear power has low total system power cost when combined with low-cost peaking generation, and the low fuel costs of nuclear units can result in heavier loadings and higher lifetime capacity factors. (D.L.C.)

**33349** THE SPECTRAL SHIFT CONTROL REACTOR. James Coughlin (Babcock and Wilcox Co., Barberton, Ohio). 17p. (CONF-51-1)

From American Public Power Assn. 20th Annual Convention, Cleveland, Apr.-May 1963.

The nuclear program of Babcock and Wilcox is described briefly. The principles of the Spectral Shift Control Reactor (SSCR) are outlined, and the design of a 450-Mw(e) SSCR power plant is described. Cost estimates for this plant indicate a total plant investment of $155/net kw and a total generating cost of 4.25 mills/net kwh. The development and economic advantages of the SSCR plant are considered briefly. (D.L.C.)

**33350** ASAE'S WORK ON HEAVY WATER REACTORS IN SWEDEN. Curt Mileikowsky (Allmanna Svenska Elektriska Aktiebolaget, Sweden). 14p. (CONF-82-6)

From Canadian Nuclear Association Conference on Heavy Water Reactors, Ottawa, May 1962.

The first industrial Swedish reactor is the Ågesta plant, also called R3/ADAM. This reactor gives a power of 65 Mw(t), of which 55 Mw(t) will be used for district heating of the homes of about 12,000 families. Also, 10 Mw(e) will be produced by the back pressure turbine. The reactor is fueled by zirconium-clad sintered natural uranium in the form of 19-rod clusters, and it is moderated and cooled by heavy water. It is of pressure vessel design. The plant is now being installed. It will be critical in about one year. The second industrial reactor of Swedish design will be the Marviken reactor, called R4/EVA. This reactor is also heavy water-moderated and fueled with uranium dioxide, clad with zirconium. Like ADAM it is of the pressure vessel type but it is in many ways improved. The pressurizing is done by heavy water steam filling the upper half of the comparatively tall pressure vessel. The fuel elements are charged and discharged through one single port-hole in the top of the reactor vessel and the fuel elements can be moved within the pressure vessel to any position by means of an internal charge machine. The pressurized heavy water main cooling circuits transfer 360 Mw(t) from the core. The light steam turbine, fed from the steam generators in the heavy water pressurized circuits, gives 105 Mw(e). The core, however, allows a much higher heat output, nearly double. This heat could be taken out by letting the heavy water steam in the upper part of the pressure vessel directly into a second turbine, the steam in the pressure vessel being continuously replaced by boiling of the heavy water in the fuel element channels. Operating in this way as a dual cycle boiling heavy water reactor, the plant would give a maximum of about 200 Mw(e). Studies of additional $D_2O$-turbine plants of 30, 53, 2 × 53, and 100 Mw(e) to be added to the pressurized water reactor have been made, giving a total power of about 145, 169, and 216 Mw(e). The choice is believed to be 30 or 53 Mw(e) additional boiling power. (auth)

**33351** BINARY CYCLE FOR NUCLEAR POWER GENERATION USING STEAM AND REFRIGERANT GASES. Nabil el-Ramly and R. A. Budenholzer (Illinois Inst. of Tech., Chicago). 19p. (CONF-15-11)

From American Power Conference, Chicago, Mar. 1963.

The steam turbine is one of the major reasons for the high generating costs of nuclear power plants. An analysis is made of the use of Freon-12 instead of steam as the

working substance in the low-pressure end of a Dresden power plant cycle employing a boiling reactor. The reduction in the heat rate by use of Freon-12 amounts to 370 and 1120 Btu/kwh at 80 and 45°F condensing temperatures, respectively, and the plant capacity could be increased by 6800 and 22,200 kw for 80 and 45°F condensing temperatures, respectively. A cost analysis indicates a justifiable added investment of 3 to 6 million dollars for equipment for the binary cycle. (D.L.C.)

**33352** HIGHLIGHTS OF OPERATING EXPERIENCE DURING PAST YEAR (1962) AT DRESDEN NUCLEAR POWER STATION. C. B. Zitek (Commonwealth Edison Co., Morris, Ill.). 13p. (CONF-15-10)

From American Power Conference, Chicago, Mar. 1963.

The gross electrical output of Dresden in 1962 was $1.25 \times 10^9$ kwh, and the capacity factor and availability were, respectively, 73 and 79.4%. The plant electrical loading is plotted, and the ten plant shutdowns are discussed in detail. Periodic control rod and drive testing, fuel element leak detection tests, and physics tests were conducted. Steps taken to increase the plant efficiency are described. The partial refueling which was carried out is discussed. Results are given of reactor component inspections and plant modifications. (D.L.C.)

**33353** THE FUTURE OF NUCLEAR SUPERHEAT AND REHEAT. R. W. Kleckner (Allis-Chalmers Mfg. Co., Greendale, Wisc.). 9p. (CONF-15-9)

From American Power Conference, Chicago, Mar. 1963.

A review is presented of the nuclear superheat and nuclear superheat-reheat programs for the improvement of nuclear power plants. These programs include Pathfinder, Borax-V, Bonus, and EVESR. Two advanced concepts of nuclear superheat-reheat plants are described (125 and 800 Mw(e)). The technical areas needing further development work are outlined, and the economics of the concepts are discussed. (D.L.C.)

**33354** EXPERIMENTAL EVALUATION OF THE FULLY LOADED ELK RIVER REACTOR. J. R. Fisher and A. Diaz (Allis-Chalmers Mfg. Co., Milwaukee). 8p. (CONF-39-15)

From American Nuclear Society Meeting, Salt Lake City, June 1963.

The loading and testing program of the Elk River Reactor confirmed the predicted values. The measured cold, clean excess reactivity agrees to 2% and the control rod worths to 1% of the calculated values. The reactivity for various core loadings and rod positions is tabulated. The effects of spiked elements on the reactivity and radial peak-to-average power ratio were studied. (D.L.C.)

**33355** OPERATING AND REFUELING EXPERIENCE AT THE YANKEE ATOMIC ELECTRIC POWER PLANT. Glenn A. Reed. 12p. (CONF-9-17)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Operation of the Yankee Atomic Electric Plant, from startup in November 1960 through February 1963, is described in detail. The reactor used the first stainless-steel-clad oxide core with boric acid as a complementary control mechanism. Reactor physics, primary plant water chemistry and radiation, and plant equipment performance are discussed for operation of the first and second cores. Refueling is also discussed in detail, including the discovery of high radiation levels due to radioactive Ag. It was discovered that Ag should never be put into a reactor unless it is completely sealed. The Ag in the Ni-plated Ag–In–Cd control rods dissolved in the oxygenated refueling water and plated out on other metals. (M.P.G.)

**33356** THE INFLUENCE OF STEAM CYCLE PERFORMANCE ON NUCLEAR POWER COSTS. A. G. Wyatt. 19p. (CONF-9-2)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

After a brief review of the general requirements of a steam cycle, the factors influencing the selection of the parameters for the CANDU cycle are considered. Consideration is then given to some of the economic factors of compound gas turbine/nuclear steam cycles and of separately fired superheat cycles, particularly as applied to possible steam conditions from Canadian power reactors. Reference is also made to flashed steam cycles, double-live steam reheat, and direct cycles. No attempt has been made to optimize particular cycles, but is hoped that the broad review of a number of different concepts will help to bring out the basic philosophy underlying steam cycle analysis. (auth)

**33357** OPERATING EXPERIENCE AT INDIAN POINT STATION. W. J. Cahill and R. H. Freyberg (Consolidated Edison Co. of New York, Inc.). 13p. (CONF-9-13)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Indian Point Station, 24 miles north of New York City on the Hudson River, produces power for the transmission and distribution system of Consolidated Edison Company. The reactor and plant are described. The cost of Indian Point is ~$1\frac{1}{2}$ times that of a conventional plant of similar capacity, but when the second core reaches equilibrium, the low fuel cost will make Indian Point Consolidated Edison's most economical plant to operate. Operation of the plant, reactor shutdowns, and general maintenance problems are discussed. The station is operating at its full capacity of 275,000 kw gross, which is at the rate of 183 million net kwh/month. (M.P.G.)

**33358** QUALITY CONTROL FOR ECONOMIC MANUFACTURE OF POWER REACTOR FUEL. W. A. Sawyer. 7p. (CONF-9-3)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Quality control programs to provide assurance that reactor fuels are manufactured in accordance with engineering drawings and specifications are described. A planned quality control system, which combines a few 100% inspections on critical characteristics with statistical quality control checks, can reduce fuel costs while maintaining the required quality level. Some features of the CANDU quality assurance program, which have had a significant effect on quality costs of CANDU fuel, are discussed. The quality costs on the CANDU fuel are less than half the quality costs on NPD fuel, but the quality assurance is greater. Methods of improving the quality control program is summarized. (M.P.G.)

**33359** THE EARLY OPERATING EXPERIENCE OF NPD. L. G. McConnell. 14p. (CONF-9-15)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

Canada's first nuclear-electric station, the "Nuclear Power Demonstration" station, uses natural U as fuel and heavy water as both moderator and coolant. The station is

described briefly, and the commissioning and early operation of the station are described in more detail. Early performance indicates that the station will meet or exceed its capacity factor objective of 80%. Costs of operation and maintenance were close to estimates. (M.P.G.)

**33360** DESIGN AND COST ESTIMATE OF A MULTIPLE UNIT $D_2O$ MODERATED AND COOLED NUCLEAR POWER PLANT. N. L. Williams. 18p. (CONF-9-18)

From CNA International Conference on the Operating Experience and Future Development of Power Reactors and on Radioisotopes, Montreal, May 1963.

The design of a four-unit nuclear generating station is described. Each unit utilizes the basic Canadian reactor and is rated at 475 Mw(e) (gross). Distinguishing features of the Canadian power reactor concept are heavy water moderator and coolant, horizontal pressure tube primary system, moderator level control, and bi-directional on-power refueling. Cost estimates indicate that the station should be competitive with reactor stations using other existing reactor concepts. Estimated total project cost is $420 million or $233/kw net. (M.P.G.)

**33361** POWER REACTOR TECHNOLOGY. Volume 6, No. 3. Walter H. Zinn (General Nuclear Engineering Corp., Dunedin, Fla.). June 1963. (GPO) $0.55 (domestic), $0.70 (foreign). (One of the Technical Progress Reviews prepared quarterly for the Division of Technical Information, USAEC). 88p.

Reviews of selected reports in the fields of power-reactor research and development, power-reactor applications, design practice, and operating experience are presented. Topics covered include: economics and applications; fluid and thermal technology; materials; containment, radiation control, and siting; design practice; operating experience; gas-cooled reactors; pressurized-water reactors; organic-cooled and organic-moderated reactors; supercritical water reactors; and physics. (M.C.G.)

## Production Reactors

**33362** (HW-71229) PERFORMANCE OF SPHERICAL NUT-CLAMP SEATING GEOMETRIES IN CONNECTOR COUPLINGS FOR NPR. W. J. Love (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Oct. 3, 1961. Contract AT(45-1)-1350. 29p.

The results of experimental and analytical investigations of the performance of spherical nut-clamp seat geometries for the NPR connector coupling clamps are summarized. Design specifications are included. Spherical nut-clamp seat geometries can limit the induced bolt bending stress in assembly lubricated couplings to reasonably small values (13,000 psi or less) under conditions of significant clamp assembly cocking. The limit of permissible clamp cocking (1 to 2°) is restricted ultimately by interference between the bolts and clamp holes. The induced bolt bending stress appears to be sensitive to the difference in nut surface-clamp seat generating radii and surface hardness with contributing effects from nut-seat surface roughness and finish of the bolt hole-seat surface edge; it is not noticeably reduced by the relative contact surface motion induced by nut tightening. Flat nut-clamp seat geometries induce bending stress linearly with the amount of clamp cocking. Additional bending stress may be introduced due to the "as manufactured" non-parallelism of clamp seat surface. Bolt bending stress values ranged from 10,000 to 120,000 psi for clamp cockings from 0 to 2°; lack of clamp seat surface parallelism under bolt load caused up to 50,000 psi of the total bending stress. A spherical-nut clamp seat can be machined into the existing flat nut clamp designs without further change. The maximum clamp flange structure stresses may be expected to be increased by 15 to 35% in the accepted design. Maximum nominal principle stresses developed in the flange under maximum normal bolt tightening loads (12,000 lb) should not greatly exceed 20,000 psi leaving a factor of safety of approximately 6. It appeared prudent to minimize bolt bending stresses by the use of assembly gages to reduce clamp cocking and spherical nuts to minimize cocking stresses. A gage procedure can prevent clamp cocking beyond the point of interference between the bolt body and clamp hole. If shim strips of suitable thickness are temporarily placed between the clamp halves during assembly, their final manual removal can assure no cocking beyond that permitted by the combined shim strip and clamp half clearance allowances. Allowances for clamp manufacturing variations indicated that a single shim thickness standard may limit clamp cocking during assembly to less than 1°. (auth)

**33363** (HW-SA-2891(Rev.)) FISSION PRODUCT CONFINEMENT FOR THE NEW HANFORD PRODUCTION REACTOR. H. S. Davis, D. D. Stepnewski, G. E. Wade, and D. L. Condotta (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). [nd]. Contract AT (45-1)-1350. 5p. (CONF-39-29)

From American Nuclear Society Meeting, Salt Lake City, Utah, June 1963.

The confinement system for protection against fission product release in the Hanford NPR after a nuclear incident is described. The secondary shielding walls and roof of the reactor heat-exchanger building function as a confiner having a volume of 2.5 million $ft^3$. This reinforced concrete structure is designed to withstand an internal pressure of 5 psig. In case of a major break in one of the large pipes of the primary coolant system, pressurized air and steam are vented from the confiner through 13 6-ft dia. ducts to the atmosphere. Automatically actuated rubber-seated butterfly valves are provided to seal the vent ducts after pressure release and before any reactor fuel melts. An exhaust system is also provided with filters capable of removing at least 99.9% of all particulate matter and 90% of the halogens. After initial venting and control of building pressure by a fog spray system, the filter ducts can be opened and the exhaust air filtered before releasing it through a 200-ft stack to the atmosphere. (M.C.G.)

**33364** INVESTIGATIONS OF URANIUM–PLUTONIUM CYCLES WITH SPECIAL REGARD TO $H_2O$-MODERATED REACTORS. PART 2. P. Wenzel (VEB EPkA, Berlin). Kernenergie, 6: 252-7(June 1963). (In German)

Discussions of U–Pu cycles for $H_2O$-moderated reactors are continued. Homogenization of the fission zone is considered. (M.C.G.)

## Research Reactors

**33365** (EUR-374.e) IRRADIATION FACILITIES IN THE ISPRA I REACTOR. M. Bresesti and H. Neumann (European Atomic Energy Community. Nuclear Research Center, Ispra, Italy). 1963. 18p.

The facilities for the irradiation of samples, available in the ISPRA I reactor are the following: isotope trains, 12 tubes in the graphite reflector under the heavy water tank; pneumatic tubes, 4 tubes delivering the samples in the graphite reflector near the heavy water tank; and 4DH1 channel facility; facility installed in a radial channel. (auth)

**33366** (GA-4333) SUMMARY OF BeO DEVELOPMENT WORK FOR THE EXPERIMENTAL BERYLLIUM OXIDE REACTOR PROGRAM. Dale E. Johnson (General Atomic Div., General Dynamics Corp., San Diego, Calif.). June 28, 1963. Contract AT(04-3)-187. 28p.

The Experimental Beryllium Oxide Reactor is described. The configurations and properties of BeO blocks are discussed. Various BeO shapes were fabricated and tested. BeO specimens of selected compositions and densities were irradiated. Dimensional changes due to radiation were in the range below 1.4% as determined from micrometer measurements. Some of the specimens in the highest exposure region of the capsule exhibited radial fractures. (M.C.G.)

**33367** (HW-69714) PHYSICAL CONSTANTS TESTING REACTOR MANUAL. H. L. Henry (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 24, 1961. Contract AT(45-1)-1350. 34p.

Operating standards, operating procedures, check sheets, temporary revisions to safety and interlock circuits, safety rules, radiation work procedures, and emergency procedures are presented for the Physical Constants Testing Reactor. (M.C.G.)

**33368** (HW-70711(Rev.)) SURGE SUPPRESSORS FOR THE PRTR PROCESS TUBE METERS. G. M. Hesson, W. L. Thorne, and J. M. Batch (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). May 1963. Contract AT(45-1)-1350. 13p.

An experimental program to devise means of reducing the oscillations of individual Plutonium Recycle Test Reactor flow monitors is described. The flow monitors use a pressure drop signal from a venturi to actuate a flow transmitter. The response characteristics of the flow monitoring equipment were determined both as installed and with various damping devices. A 3- to 4-foot length of $\frac{1}{16}$-inch tubing was found to adequately reduce oscillations without unduly lengthening the response of the flow monitor. (auth)

**33369** (HW-75045) CALCULATED FISSION PRODUCT RELEASE FROM PRTR RUPTURE. J. A. Stoddard (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Sept. 28, 1962. Contract AT(45-1)-1350. 13p.

Approximately 15 minutes after shutdown on August 21, 1962, evidence of a rupture was observed in the form of high radiation levels in the containment vessel and rupture monitor indications. Discharge of a special $MgO-PuO_2$ test element revealed a cladding break of about 1.5 in. in length and about $\frac{1}{4}$ in. wide in the widest place, located 36 in. from the top of the fuel element. A visual examination revealed that approximately 9.25 in. of fuel material or about 0.55% of the entire fuel element had escaped. The quantities and radiation levels from the individual fission product isotopes were calculated and are presented in tables. The curies of various isotopes released by the rupture for 10, 30, 90, and 180 days after the rupture occurred are given. The radiation levels one foot from an unshielded point source containing the various isotopes are given. The radiation levels one foot from a point source shielded by one inch of steel are also given. The surface dose rate for the 14-in. primary piping if each isotope were dissolved uniformly in the primary coolant is included. Fission products having less than a one-day half life were ignored unless they had a long lived precurser. (auth)

**33370** (HW-SA-3098) PLUTONIUM RECYCLE TEST REACTOR PRIMARY COOLANT PUMPS. P. A. Scott (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). July 5, 1963. Contract AT(45-1)-1350. 23p. (CONF-102-1)

For Presentation at Winter Meeting of ASME, Philadelphia, Pennsylvania, Nov. 1963.

The Plutonium Recycle Test Reactor primary coolant pumps use face type mechanical shaft seals and incorporate a large flywheel for emergency flow during power outages. The test and development work preceding and during initial PRTR operation revealed several major problems. These problems and their solutions are discussed. Mechanical seal life was extended from original rapid failures in a few hours to periods of several thousand hours. (auth)

**33371** (IDO-16871-1) FUNDAMENTALS IN THE OPERATION OF NUCLEAR TEST REACTORS. VOLUME 1. REACTOR SCIENCE AND TECHNOLOGY. (Phillips Petroleum Co. Atomic Energy Div., Idaho Falls, Idaho). June 1963. Contract AT(10-1)-205. 147p.

A résumé of nuclear physics basic to reactor operation precedes discussion of aspects of reactor physics, engineering, chemistry, metallurgy, instrumentation, control, kinetics, and safety. The object is to provide an approach to and understanding of problems in irradiation test programs in the Materials Testing and Engineering Test Reactors. (D.C.W.)

**33372** (JÜL-125-RE) WASSERDURCHFLUSSMESSUNGEN IM KOMPAKTEN KERN DES FRJ-1. (Water Discharge Measurement in Compact Core of FRJ-1). J. Jacquemin (Kernforschungsanlage, Jülich, Germany). June 1963. 24p.

On the lattice slab of the reactor a compact core was formed with 17 fuel element mockups, of which 6 were provided with baffle tubes for measurement of flow. The remaining part of the lattice is composed of 14 reflector elements and 46 blank elements. The flow was measured in both experimental planes; it amounted to, on the average, about 14 $m^3/hr$ per fuel element. In following steps up to 11 blank elements on both sides of the core were removed from the lattice. That caused a decrease in flow per fuel element to about 8.2 $m^3/hr$. In a special testing arrangement, the standard curve for a baffle tube was plotted. By means of a slight modification of the testing arrangement it is possible to perform standard measurements for blank and reflector elements. On the basis of theoretical considerations and the standards, the pressure difference over the core was ascertained to be 0.16 $kg/cm^2$. At the inlet and outlet of the primary pumps the total pressure difference in the primary circuit was measured as about 1.89 $kg/cm^2$. (tr-auth)

**33373** (NP-12998) APTR CRITICAL EXPERIMENT HAZARD SUMMARY REPORT. (AMF Atomics. Div. of American Machine and Foundry Co., Greenwich, Conn.). June 1963. 110p.

A critical experiment for the Advanced Pressure Tube Reactor (APTR) in the IRL Reactor is described and safeguards taken to reduce the consequences of potential hazards are described. The APTR core is a water-moderated, beryllium- and water-reflected flux trap type with an annular fueled region utilizing 90% enriched uranium. The calculated core physics characteristics for the critical experiment are given. The maximum credible accident would result in a total energy release of less than 1.3 Mw-sec. (M.C.G.)

**33374** (ORNL-TM-605) EXPERIENCE WITH THE USE OF THE ROD-DROP METHOD OF ROD CALIBRATION AT THE ORR AND LITR. Frederick B. Buoni (Oak

Ridge National Lab., Tenn.). Aug. 6, 1963. Contract W-7405-eng-26. 24p.

The rod-drop method was examined as a means of determining the shutdown worth of the LITR and ORR shim rods. The results obtained for the LITR are in close agreement with integral rod worths obtained previously by period methods. A procedure for calibration of rods that is applicable to both the LITR and ORR is given, and tables to permit rapid calculation of the shutdown $\Delta k$ are presented. The method gives results reproducible to within 12% in comparing rod worths over a series of tests. (auth)

**33375** (ORNL-TM-638) REVISIONS TO MSRE DESIGN DATA SHEETS, ISSUE NO. 7. R. B. Lindauer (Oak Ridge National Lab., Tenn.). Aug. 2, 1963. Contract [W-7405-eng-26]. 38p.

Revised design data sheets are presented for the Molten Salt Reactor Experiment operating at a power level of 10 Mw. This issue covers nuclear data, major components, auxiliary components and systems, and special materials. (auth)

**33376** THE RESEARCH REACTOR SILOE. Assoc. Belge Develop. Pacifique Energie At., Bull. Inform., 8: No. 43, 11-15(Apr. 1963). (In French)

The SILOE Reactor is a swimming pool reactor with a power of 15 kw(t). The neutron flux available is $10^{11}$ n/cm$^2$/sec. The reactor is described, and its nuclear and physical characteristics are tabulated. (J.S.R.)

**33377** MECHANICAL ENGINEERING ACTIVITIES IN THE SUSPENSION REACTOR PROJECT. H. Wolf. Atoomenergie Haar Toepassingen, 6: 109-19(June 1963). (In Dutch)

In the preceding articles of this series the KEMA project for the development of a suspension reactor was explained in general terms. In this article, mechanical engineering aspects were discussed in greater detail. A review was given of the preliminary investigations for the design, construction, and operation of the KSTR (KEMA Suspension Test Reactor). (tr-auth)

**33378** CONCRETE FOR BIOLOGICAL SHIELDING FOR THE NAHAL SOREQ ATOMIC REACTOR. R. Malinowski (Israel Inst. of Tech., Haifa). Bull. Res. Council Israel, Sect. C, 11: 297-312(Apr. 1963).

Technical requirements with regard to the concrete for biological shielding at the Nahal Soreq reactor are discussed. Special emphasis is placed on certain problems of more general character, such as: a method for designing barytic concrete mixes, based on unit weight as a design factor; problems of barytic concrete casting in hot dry climate; a method of compacting by vibration in close proximity to and underneath radiation installations; use of perspex models for control of the concrete and concreting methods; control of the density and uniformity of the concrete in the walls by means of ultrasonic waves. (auth)

**33379** BEAM-TUBE DESIGN FOR THE HIGH-FLUX BEAM REACTOR. H. Kouts (Brookhaven National Lab., Upton, N. Y.). J. Nucl. Energy, Pt. A & B, 17: 153-63(July 1963). (BNL-6742)

The reactor is designed to provide very intense neutron beams and beams that are tailored to particular experiments. Critical experiments were performed to select the parameters for the reactor and its facilities. Experiments pertaining to beam tube optimization are discussed along with the design of the reactor and its facilities. (D.C.W.)

**33380** A GLOBAL PILE OSCILLATOR FOR THE ROSSENDORF RESEARCH REACTOR. P. Liewers (Zentralinstitut für Kernphysik, Rossendorf, Ger.). Kernenergie, 6: 263-7(June 1963). (In German)

A pile oscillator is described, which is installed in the Rossendorf Research Reactor (RFR). A hydraulic oscillation arrangement moves the sample periodically between the center and edge of the fission zone with a frequency of 0.05 Hz. The electronic measurement arrangement, at a reactor power of 500 w, possesses a sensitivity of $\pm 10^{-7}$. This sensitivity could only be increased by an efficient drift elimination system, which on the basis of the frequent 2-Mw operation of the RFR sets no poison equilibrium at lower powers. For absorption-cross-section measurements, a sensitivity of $\pm 0.25$ mm$^2$ was achieved. (tr-auth)

**33381** SHIELDING MEASUREMENTS AT THE WWR-S REACTOR. K. Faehrmann (Zentralinstitut für Kernphysik, Rossendorf, Ger.). Kernenergie, 6: 268-73(June 1963). (In German)

The accomplishment of shielding measurements on the Rossendorf Research Reactor is reported. The experimental construction and the measurement arrangement are described and the applicable measurement corrections are explained. Diminishing patterns for the fast, epithermal, and thermal neutrons in water and different iron–water configurations are cited. (tr-auth)

**33382** OPERATING UNIVERSITY REACTORS WITHIN THE MYRIAD OF LOCAL, STATE AND FEDERAL REGULATIONS. Forrest J. Remick (Pennsylvania State Univ., University Park). Nucl. News, 6: No. 6, 3-5(June 1963).

Some of the problems associated with operating university research reactors resulting from the increased complexity and number of local, state, and federal regulations is presented. The effects on reactor operations are also dealt with. (R.E.U.)

# SPACE APPLICATIONS AND TECHNOLOGY

*Refer also to abstract 33388.*

**33383** OUTLOOK FOR GAS-CORE NUCLEAR ROCKETS. Robert G. Ragsdale (Lewis Research Center, Cleveland). Astronaut. Aerospace Eng., 1: No. 7, 88-91(Aug. 1963).

Performance improvements for a gas-core nuclear rocket are discussed. The hydrodynamic, heat-transfer, and nucleonic processes involved in the hydrogen and gaseous uranium-235 propulsion system are considered. Current research and future goals are also discussed. (C.E.S.)

**33384** WHAT KIND OF UPPER-STAGE PROPULSION FOR MARS MISSIONS? Arnold D. Cohen and Lewis S. Beers (General Electric Co., Valley Forge, Penna.). Astronaut. Aerospace Eng., 1: No. 7, 98-105(Aug. 1963).

A comparison of chemical, nuclear heat transfer, and electrical propulsion systems for Mars missions is presented. A probe, Mars orbiters, and soft-landing missions were selected as best typifying the energy requirements. The use of chemical upper stages with Atlas-Centaur booster, electric propulsion with Saturn C-1B, and nuclear or electric propulsion with Saturn C-5 and Nova is indicated for the 1965-1980 period. (C.E.S.)

**33385** MANAGING THE NUCLEAR-ROCKET PROGRAM. Harold B. Finger (Space Nuclear Propulsion Office, Washington, D. C.). Astronautics, 7: 18-21(Dec. 1962).

The management philosophy and organization of the U. S. nuclear-rocket program are discussed. Techniques for controlling and coordinating all program aspects are reviewed. In addition, advantages of nuclear rockets, in view of their payload capabilities over purely chemical systems, are pointed out. (Intern. Aerospace Abstr.)

**33386** ATOMARE TRIEBWERKE FÜR DIE RAUMFAHRT. (Nuclear Propulsion Systems for Space Flights). Robert E. Mayes. Flugwelt, 14: 1004-7(Dec. 1962).

The design characteristics and the principles of operation of nuclear propulsion systems for space vehicles are given. Some of the problems encountered in the construction of nuclear propulsion systems, such as guidance and radiation shielding, are briefly discussed. In addition, an account is given of Project Rover and of the test reactors of the Kiwi series. (Intern. Aerospace Abstr.)

**33387** PROPULSION FOR SPACE VEHICLES: A SURVEY. H. S. Seifert (United Technology Corp., Sunnyvale, Calif. and Stanford Univ., Calif.). Space Sci. Rev., 1: 331-64(Oct. 1962).

The various propulsion systems for space travel are surveyed, emphasizing the propulsion requirements of various missions. Liquid-, solid-, and hybrid-propellant rocket engines, and nuclear, arc-jet, ion-accelerator, magnetogasdynamic, solar-sail, solar-collector, and matter-conversion propulsion methods are considered. Performance characteristics of some of the systems are included. (Intern. Aerospace Abstr.)

**33388** DESIGN SAFETY PROBLEMS OF NUCLEAR REACTORS IN SPACE FOR ELECTRICAL POWER. D. A. Pickler (Lockheed Missiles and Space Co., Sunnyvale, Calif.). 15p. (CONF-67-1)

From Health Physics Society Meeting, New York, June 1963.

A general treatment is presented of some of the problems in the design safety of reactors which are to be operated in space. The basic requirements of these reactors are light weight, safety, reliability, and operation at high temperatures. The usual concept of a space reactor is described briefly, and the hazards of an assumed unmanned vehicle with an enriched-U-fueled reactor are examined during its launching, orbit, and reentry. Graphs are given for the dose vs distance downwind for an excursion of 100 Mw-sec, for the activity vs time after shutdown of a reactor which has been operated for 5 yr at 100 kw(t), and for the altitude vs orbital lifetime. Apparent conflicts between the basic requirements are discussed. (D.L.C.)

**33389** PROBLEMS OF INSTRUMENTATION AND CONTROL FOR NUCLEAR ROCKETS. Paul Erskine Brown (Radio Corp. of America, Princeton, N. J.). 9p. (CONF-79-1)

From American Inst. of Aeronautics Manned Space Lab. Conference, Los Angeles, May 1963.

The principles and efficiency of the nuclear rocket are described briefly, and the environment around the rocket is considered. The problems and requirements of the control system of the nuclear rocket are outlined. The state-of-the-art of both control systems and nuclear instrumentation is reviewed in some detail. A bibliography of 61 references is given. (D.L.C.)

**33390** POTENTIALITIES OF THE RADIOISOTOPE ELECTROSTATIC PROPULSION SYSTEM. William R. Mickelsen and Charles A. Low, Jr. (Lewis Research Center, Cleveland). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63048-63, 13p. (CONF-10-56)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

Anticipated availability dictates the choice of cerium-144 as fuel for radioisotope electrostatic propulsion systems. With appropriate vehicle design, the gamma dosage can be acceptable for unmanned probe vehicles even without shielding. Good mission performance can be obtained with vehicles small enough for convenient mating with existing chemical boosters. Although launch-pad and boost-phase radiation hazards are serious problems, practical solutions may be possible. Manned interplanetary missions that require solar-flare absorption shielding appear to be feasible with this propulsion system. (auth)

**33391** A PARAMETRIC STUDY OF DIRECT NUCLEAR ELECTROGENERATOR CELLS USING A BETA EMITTING SOURCE. Allan J. Cohen and Charles A. Low, Jr. (Lewis Research Center, Cleveland). New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63048B, 15p. (CONF-10-57)

From Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

A design analysis is completed for direct nuclear electrogenerator cells using the beta emitting radioisotope cerium-144. The physical phenomena that complicate the design are the beta particle energy spectrum, the energy losses in the fuel and support foil, and the relativistic motion of the particle in the electric field. In addition to these physical restrictions, the various cell parameters such as radius ratio, fuel layer thickness, support foil

thickness, and collector thickness are interrelated in such a complex manner that the IBM 7090 digital computer is required to find the characteristics of the cells. Cylindrical and spherical geometries are studied to determine the minimum weight per unit power. The main details of the mathematical operations performed by the computer are outlined along with information pertinent to the input requirements and results of the program. The simple calculations necessary to complete the description of the specific cells are indicated. The cell characteristics that result from these procedures are the operating voltage, current and power per unit area, the temperatures of the emitter and collector, and the weight per unit power. From these characteristics, the cell parameters that yield the optimum feasible design can be logically determined by simple analytical methods, which are described. As a result of these studies, a few designs are presented that can have weight/power ratios of 0.3 to 0.5 kg/kw. The study shows that within reasonable construction and physical limits a simple, efficient, and lightweight direct nuclear electrogenerator can be designed for space power uses. (auth)

**33392** SNAP 8 REACTOR AND SHIELD. C. A. Johnson and C. A. Goetz (Atomics International, Canoga Park, Calif.). New York, American Inst. of Aeronautics and Astronautics, 1963, Preprint 63-033, 29p. (CONF-10-60)

From AIAA Electric Propulsion Conference, Colorado Springs, Colo., Mar. 1963.

SNAP 8 is a nuclear powerplant intended to produce approximately 30 kw of electric power output for use in spacecraft. The system employs a nuclear reactor as the heat source for a mercury Rankine cycle power conversion system. Information is given on the design of the SNAP 8 reactor and shield. The performance requirements, design, weight, and operating characteristics of the SNAP 8 reactor are summarized and a typical shield is discussed. The effects of spacecraft configuration and payload dose tolerance on shield weight for unmanned spacecraft are discussed. Approximate relationships are presented to facilitate rough estimates of shield weights for preliminary design studies of unmanned spacecraft employing the SNAP 8 reactor. (auth)

**33393** MATERIALS PROBLEMS ASSOCIATED WITH THE DESIGN OF RADIATORS FOR SPACE POWERPLANTS. James H. Diedrich (Lewis Research Center, Cleveland). 20p. (CONF-94-4)

From American Nuclear Society Meeting, Nuclear Materials for Space Application, Cincinnati, Apr. 1963.

The Rankine cycle turbogenerator and thermionic emitter (both employing a nuclear energy source) have the greatest potential for producing a minimum weight system (~10 to 20 lb per electric kw output), but for both large amounts of waste heat must be rejected in space by radiation. Environmental factors and design considerations that will influence the materials selection for the radiator are discussed. Parameters that reflect minimum weight and meteorite penetration resistance are used to evaluate several candidate materials for a tubular-fluid radiator. The results indicate that beryllium and pyrolytic graphite will be best, but preliminary hypervelocity impact tests indicate a need for further development work on beryllium. (D.L.C.)

**33394** FUEL CONTAINMENT IN THE GASEOUS-CORE NUCLEAR ROCKET BY MHD-DRIVEN VORTICES. Jacob B. Romero (Boeing Co., Seattle). 40p. (CONF-8-2)

From American Inst. of Chemical Engineers Meeting, Buffalo, May 1963.

An MHD-driven vortex is considered for fuel retention in the gaseous-core nuclear propulsion engine. The characteristics of the vortex are obtained from the flow, diffusion, and electromagnetic equations. A simplified method of solution employing arbitrary temperature distributions is used. Rocket engine performance is estimated for two design concepts: a single critical vortex tube and multiple vortex tubes. Both designs are limited by electrical requirements, pressure gradients, and other design considerations. Engine thrust-to-weight ratios in the order of $10^{-2}$ and 0.4 are obtained for the single-vortex and multiple vortex concepts, respectively. Performance improvement may be possible by employing bypass flow systems. (auth)

# WASTE DISPOSAL AND PROCESSING

**33395** (HW-SA-2786) DEVELOPMENT OF RADIOACTIVE WASTE FRACTIONIZATION AND PACKAGING TECHNOLOGY. Warren V. DeMier, Gerald L. Richardson, Allison M. Platt, and Ward H. Swift (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Jan. 23, 1963. Contract AT(45-1)-1350. 35p. (CONF-8-3)

From American Institute of Chemical Engineers Meeting, Buffalo, N. Y., May 1963.

Processes are being developed to achieve removal of the long-lived heat generating fission products $Sr^{90}$ and $Cs^{137}$ from high-level wastes. Included are methods for packaging $Sr^{90}$ and $Cs^{137}$ in small-volume, high-integrity containers for long term storage or potential utilization. Solvent extraction, ion exchange, and precipitation processes and equipment to perform the fission product removal function are described. Di-2-ethylhexyl phosphoric acid is employed for strontium solvent extraction. Solvent extraction, cation exchange, and various precipitation processes are applicable to cesium removal. Packaging techniques for the isolated strontium and cesium employ ion exchange absorption on synthetic inorganic zeolites followed by thermal stabilization and encapsulation. (auth)

**33396** (HW-SA-2920) INORGANIC ION EXCHANGE SEPARATION OF CESIUM FROM PUREX-TYPE HIGH-LEVEL RADIOACTIVE WASTES. J. L. Nelson, G. J. Alkire, and B. W. Mercer (General Electric Co. Hanford Atomic Products Operation, Richland, Wash.). Feb. 25, 1963. Contract AT(45-1)-1350. 23p. (CONF-14-8)

From American Chemical Society Meeting, Los Angeles, Calif., March–April 1963.

A chemical flowsheet for the separation of cesium from acid Purex formaldehyde-treated waste (FTW) using the mineral clinoptilolite is presented. Breakthrough curves for cesium, sodium, cerium, strontium, ruthenium, and niobium are shown. In loading cesium from FTW on clinoptilolite, cesium ions are concentrated on the exchanger to such an extent that they begin to compete appreciably with each other for sites rather than with sodium and hydrogen only. In elution of cesium from clinoptilolite, the ammonium ion is not so efficient as potassium and rubidium but it is much easier to separate from cesium. (M.C.G.)

**33397** (ORNL-TM-595) SHIELDING CALCULATIONS POT CALCINATION DEMONSTRATION AT HANFORD. J. M. Holmes, H. Pfohl, and E. D. Arnold (Oak Ridge National Lab., Tenn.). June 21, 1963. Contract W-7405-eng-26. 15p.

The results of shielding calculations are presented for the Pot Calcination Demonstration at Hanford. Stored pots containing Consolidated Edison waste cooled 180 days produced the highest dose rate of 18 mrem/hr through a 64-in. concrete shield. Purex waste (180-day cooled) in 8-in.-diameter pots gave 4.2 mrem/hr through the same shield. Purex waste source activities and fission product heating data are also presented. (auth)

**33398** TREATMENT AND STORAGE OF HIGH-LEVEL RADIOACTIVE WASTES. Proceedings of the Symposium Held in Vienna, 8-12 October, 1962. (International Atomic Energy Agency, Vienna). Proceedings Series. Feb. 1963. 663p. (STI/PUB/63). $13.00. 273s; NF 52; DM 45 (IAEA)

Separate abstracts were prepared on 12 papers included in this report. (C.H.)

**33399** PRESENT AND FUTURE PROGRAMMES IN THE TREATMENT AND ULTIMATE DISPOSAL OF HIGH-LEVEL RADIOACTIVE WASTES IN THE UNITED STATES OF AMERICA. W. G. Belter (Atomic Energy Commission, Washington, D. C.). p.3-22 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In English)

The inherent restrictions of tank storage for high activity waste, such as potential leakage and the necessity of liquid-waste transfer for periods of hundreds of years, has resulted in a vigorous research and development program directed at engineering practical systems for the ultimate disposal of these materials. The program in the Atomic Energy Commission Reactor Development Division is described as it relates to the development of a future nuclear power economy. The long-range waste management program at the plutonium production centers, Hanford and Savannah River, with their particular site requirements, are briefly summarized. Several conversion to solids methods, including the use of fluid beds, heated pots, radiant-heated spray columns, rotary kilns, and ceramic sponges are reported to be under study. The addition of glass-forming materials to the waste for the purpose of providing a more stable final product is also being investigated. Some of the advantages and disadvantages of each process are noted. The present status of these development projects is summarized and the proposed future plans are stated. The investigation of specific geologic formations such as salt structures, deep permeable basins, and impermeable crystalline rock for the ultimate storage or disposal of calcined solids or certain types of liquid wastes is described. Plans for a proposed field experiment in salt with full-scale activity are discussed. The exploratory drilling program at the Savannah River Plant to determine the feasibility of storing aged, first-cycle wastes in the basement rock below SRP is briefly described and preliminary results noted. Brief reference is made of the long-range engineering studies being conducted at Oak Ridge to evaluate the hazards and economics of various methods for handling, storage, and/or ultimate disposal of highly radioactive liquid and solid wastes. The role of this engineering evaluation program in relation to future program planning in waste management is discussed. (auth)

**33400** ON THE INFLUENCE OF NITRATES ON THE COMPOSITION OF VAPOUR PHASE OVER NITRIC ACID SOLUTIONS. A. N. Efimov, M. I. Zhikharev, and Yu. P. Zhirnov. p.133-9 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In Russian)

Experimental data are presented for vapor liquid equilibrium and boiling-point temperatures at a pressure of 760 mm Hg, for part of the nitrate-nitric acid-water systems. Systems with nitrates of Al, Fe, Mg, Cu, Na, and $NH_4$ were studied. A method of calculating the evaporation process in waste solutions obtained from the reprocessing of irradiated fuel elements is described. The high-activity, nitric-acid waste solutions are formed during the extractive reprocessing of irradiated fuel elements. These solutions themselves constitute complex systems, composed of a series of nitrates, in addition to volatile components such

as water and nitric acid. Evaporation is usually carried out to reduce the volume of the waste solutions before burial, and in the course of evaporation, nitric acid is driven off. The nitrates in the waste solutions have a definite influence on the distribution of nitric acid between the vapor and liquid phases during evaporation. An attempt was made to determine this influence for each nitrate, by investigating the vapor/liquid equilibrium in part of the nitrate-nitric acid-water systems. (auth)

**33401** FISSION-PRODUCT SEPARATION AS A FINAL SOLUTION TO THE PROBLEM OF STORING HIGHLY RADIOACTIVE WASTE. A. Raggenbass and J. Lefevre (CEN, Saclay, France). p.141-52 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In French)

The separation of $Cs^{137}$ and $Sr^{90}$ from solutions of concentrated fission products is discussed. It is pointed out that a decontamination factor of at least $10^4$, after conventional effluent processing, would allow effective disposal within 10 to 20 years time. Methods for the precipitation of $Cs^{137}$ and $Sr^{90}$ are described. Cladding of strong sources before storage is suggested as a reliable method for radiation protection. (C.H.)

**33402** CALCINATION OF RADIOACTIVE WASTE IN MOLTEN SULPHUR. W. E. Winsche, M. W. Davis, Jr., C. B. Goodlett, Jr., E. S. Occhipinti, and D. S. Webster (E. I. du Pont de Nemours and Co., Aiken, S. C.). p.195-216 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In English)

A process is described for the calcination of radioactive waste that is based on the unique properties of sulfur for converting radioactive wastes to a solid form of low solubility for ultimate disposal. In this process the aqueous acidic wastes are reacted with molten sulfur at 150°C so that the water and volatile acids are driven off and the chemical compounds present in the waste are calcined and/or chemically reduced. The resulting sulfur-waste slurry is then heated at 400 to 444°C for from 1 to 5 hr to drive off sulfuric acid and residual water and further calcine and/or reduce the chemical compounds in the sulfur-waste slurry. In these steps the molten sulfur serves as a heat-transfer medium, prevents the entrainment of the radioactive solids in the stream and reaction gases and eliminates the volatilization of radioactive ruthenium by preventing the formation of the tetroxide. Laboratory scale runs with concentrated high activity waste as feed ($1.3 \times 10^5$ $\gamma$ c/(min)(ml), 2.0 M $Al(NO_3)_3$, and 1.5 M $HNO_3$) have shown that only one part in approximately 100,000 parts of the activity in the feed is carried overhead in the off-gas in these process steps. After the completion of the high-temperature treatment, the sulfur-waste slurry is cooled to 120 to 150°C and transferred as a liquid to the final containment system where it is allowed to solidify. The resistance of the solidified sulfur-waste slurry to the action of water was used as a measure of the effectiveness of this process. Small cylinders of the solidified slurry were prepared from simulated wastes containing $Al(NO_3)_3$ or dissolved stainless-steel nitrates with tracer levels of Sr and Cs, and for concentrated high-activity waste containing $Al(NO_3)_3$. These cylinders were exposed to water over extended periods of time. Leaching rates were calculated as though there was complete removal of material from a surface layer. Rates of 10 to 20 mil/yr, or less, were observed after an initial period of 6 to 8 weeks at moderately higher rates. (auth)

**33403** POT-CALCINATION PROCESS FOR CONVERTING HIGHLY RADIOACTIVE WASTES TO SOLIDS. J. M. Holmes, R. E. Blanco, J. O. Blomeke, W. E. Clark, H. W. Godbee, C. W. Hancher, J. C. Suddath, and M. E. Whatley (Oak Ridge National Lab., Tenn.). p.255-86 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In English)

The pot-calcination process has successfully converted synthetic non-radioactive Purex, TBP-25 (aluminium, $HNO_3$), and Darex (stainless steel, $HNO_3$) wastes to solids in both bench-scale (24 × 4 in. diam.) and engineering-scale (82 × 8 in. diam.) pots. The process includes feed evaporation, calcination to 900°C in the pot, and recycle of the calciner vapor to the evaporator in a closed loop. Vapour from the evaporator is fractionated to produce water for disposal and nitric acid for re-use. The stainless-steel pot would be sealed after being filled and would serve as both the shipping and ultimate containment vessel. The nitrate content of the calcined solids varied between 60 and 550 ppm. Sulfate volatility during calcination of Purex waste was reduced to less than 0.8% by conversion to thermally stable sodium, magnesium, or calcium salts. Ruthenium volatility from the pot was reduced to less than 20% of the feed by the addition of phosphite or nitric oxide gas to the calciner. Steam stripping to avoid excessive acid build-up in the evaporator limited the volatility of ruthenium from the evaporator to approximately 2% of the feed. Addition of up to 1 ml/l each of monobutyl and dibutyl phosphate to the feed to simulate solvent degradation products reduced the ruthenium volatility to <1%. The mercury in TBP wastes was completely volatilized during calcination. Control of a 25 to 1 hold-up continuous evaporator close-coupled to the engineering-scale pot calciner was demonstrated and a batch evaporation system was developed during 25 experimental tests. Average feed rates for both systems varied between 8 and 30 1/hr. Small-scale equipment (24 × 4-in.-diam. pots) for studying fission product volatilities from actual wastes is installed in a hot cell at Oak Ridge National Laboratory. A 20 to 1/hr pilot plant for calcination of radioactive Purex, Darex, and TBP-25 wastes in 82 × 6 to 12-in.-diam. pots is being designed for installation at the Idaho Chemical Processing Plant. Provisions will also be included for production of glassy solids in the calciner pots. A program on mechanical aspects is in progress to develop methods for remotely connecting the calciner pots to the pilot-plant system and setting them for permanent storage. (auth)

**33404** ON THE BEHAVIOR OF RADIOISOTOPES INCORPORATED IN GLASS BLOCKS. P. V. Zimakov, V. V. Kulichenko, F. S. Dukhovich, and B. A. Salamatin. p.397-410 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In Russian)

As several isotopes have a long half-life, it is necessary to ensure that they remain securely fixed over a lengthy period. This necessitates study of their behavior in vitreous blocks after prolonged storage, during which spontaneous heating and radiation occur, and they are submitted to influence of the environment. The efforts made to reduce the volume of the blocks for burial and to lessen the volatility of the isotopes during preparation (temperature not exceeding 1200°C) result in the blocks acquiring a heterogeneous structure, so that they are no longer true glasses but vitreous compounds. The characteristics of such blocks and their ability to immobilize fission isotopes depends to a great extent on their chemical composition (quantity and nature of flux), manner of preparation and subsequent stor-

age. Temperature rises brought about by the release of heat from the high-activity blocks in the burial ground lead to chemical and physical processes within them and greatly influence the retention of wastes, especially at the block surfaces. The leachability of isotopes from vitreous blocks normally increases once the temperature exceeds 400°C. It is therefore inadvisable to allow excessively high temperatures to build up in the burial grounds. The high level of radiation from high-activity blocks also has a marked influence on changes in the structure of the blocks and consequently in the durability of the bond between them and the fission isotopes. The changes also proceed in the first instance from surfaces in contact with the surrounding media (air, water). The leachability of isotopes from radioactive blocks normally increases. An increased release of radioisotopes from the surface into gaseous phase was established experimentally in the case of radioactive blocks. In view of all the influences to which the vitreous blocks are subject over a considerable time, their chemical composition and manner of preparation (flux) must be carefully selected so as to ensure that the radioisotopes remain securely fixed in the buried blocks. In this connection, titanium compounds are especially interesting as fluxes. (auth)

**33405** FIXATION OF SIMULATED HIGHLY RADIOACTIVE WASTES IN GLASSY SOLIDS. W. E. Clark and H. W. Godbee (Oak Ridge National Lab., Tenn.). p.411-39 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In English)

Current laboratory development work at ORNL aims at incorporating high-activity-level wastes in high-density insoluble glasses, containing all radioactive constituents in the solid. Experiments with simulated TBP-25 (aluminium, $HNO_3$), Purex, and Darex (stainless steel, $HNO_3$) wastes have indicated the technical feasibility of such a process. Dense, microcrystalline solids may be as acceptable as true glasses; their greater thermal conductivity compensates somewhat for the increase in surface area over that of true glasses. Phosphate and borophosphate glasses were prepared from all three types of waste in the laboratory. Cesium volatility was limited to the ~0.1% due to physical entrainment, and ruthenium volatility was lowered to <0.5% by addition of phosphite or hypophosphite. Other additives included PbO, $Ca(OH)_2$, NaOH, and MgO. Bulk densities varied from 2.36 to 2.90 g/cm$^3$ for TBP-25 and from 2.63 to 2.80 g/cm$^3$ for Purex waste. Corresponding volume reductions from the concentrated waste solutions were 7.2 to 9.3 and 5.7 to 8.3; initial softening points varied from 875 to 1000°C and from 830 to 975°C respectively. Darex tests are still preliminary. Semi-continuous operation on a semi-engineering scale produced a true glass from TBP-25 waste and a microcrystalline solid from Purex. The thermal conductivity of the glass varied from 1.05 BTU/hr-ft-F° at 320°F to 1.6 at 1050°F, about 10 times higher than that of the calcine without additives. Ruthenium volatility was held to <10% by phosphite addition. Stainless steel is a satisfactory material for construction of the calcination-fixation container. Essentially all the internal corrosion takes place during the relatively short (2-6 hr) period in which the last of the acid and water is expelled at the maximum temperature. Melt production increased the corrosion of 304L stainless steel from 5 to 42 mil/month for a 24-hr evaporation-fixation cycle on TBP-25 waste and from 8 to 140 mil/month on Purex waste. Operation above 900°C with Purex waste plus fluxing agents may result in catastrophic local corrosion. (auth)

**33406** SOLIDIFICATION OF RADIOACTIVE WASTE SOLUTIONS. N. E. Brezhneva, Yu. N. Golovanov, S. N. Oziraner, A. A. Eremin, and V. N. Rozanova. p.441-63 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In Russian)

The results are presented from the experimental development of a method for the solidification of radioactive waste solutions, based on the drying and vitrification of precipitates of iron-hydroxide obtained by settling from radioactive solutions. The solidification system is based on the principle of maximum reduction of the waste off-gases after removal of the aerosols and volatile radioactive components. Optimum conditions to obtain a chemically stable glass and lower the temperature for the melting of the glass by modifying the fluxes added are described. An appreciable drop in the chemical stability of the glass was noted when it was stored for a long time at temperatures above 300 to 350°C. The authors studied the leachability of radiocesium from the glass. They also investigated the volatility of radiocesium and radioruthenium in the course of drying and melting and showed that in an atmosphere of carbonic acid gas the volatility of ruthenium completely disappears. The volatility of radiocesium in appreciable quantities became noticeable at temperatures above 700°C and increased as the temperature rose. It was shown that radiocesium condenses in the drainage tubes at temperatures below 400°C and is easily washed off by weak solutions of nitric acid and water. Calculations of the heat release from radioactive glass showed that the radius of globular glass castings from high-activity materials (10 c/g) must not exceed 25 cm. The flowsheet for a process for the drying and vitrification of radioactive sludge by means of a gas- and heat-remover, together with details of the apparatus required, are included. (auth)

**33407** THE HEAT RELEASE FROM HIGH-ACTIVITY SOLID SUBSTANCES IN RELATION TO THE PROBLEM OF THEIR BURIAL AND USE. P. V. Zimakov, B. S. Kolychev, V. V. Kulichenko, and Yu. P. Martynov. p.543-50 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In Russian)

Heat release is of special significance when transforming high-activity liquid wastes into solid substances, and especially when these solids are buried. One possible way of taking off and using the heat in the melting of glass-forming mixtures is considered. This method makes it possible to keep temperature increases in the burial grounds within given limits without resorting to external cooling. In the long run, this method may provide a means for the safe disposal of high-activity substances for an indefinite period. (auth)

**33408** TREATMENT OF HIGHLY ACTIVE LIQUID WASTES BY MINERAL ION-EXCHANGER SEPARATION. L. Baetslé and P. Dejonghe (CEN, Mol, Belg.). p.553-67 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In French)

The method studied at the BELCHIM-CEN Laboratories at Mol is based on a partial deacidification of the highly acid effluent and the complete separation of the $Sr^{90}$ and $Cs^{137}$ isotopes by selective adsorption on mineral ion exchangers. After storage and simple chemical treatment, the mother liquor may then be discharged. Preparation methods, structure and exchange properties in different media were studied in respect of two mineral ion ex-

changers, zirconium phosphate and ferrocyanide molybdate complex. The results of $Cs^{137}$ and $Sr^{90}$ separation by means of these exchangers are given. The decontamination factors obtained with synthetic solutions (Purex) were at least $10^8$ in respect of $Cs^{137}$ and $Sr^{90}$. By selecting appropriate elution conditions it was possible to recover, in 5 vol. of eluent beds, 99.9% of $Cs^{137}$, adsorbed on zirconium phosphate. (auth)

**33409** STUDIES OF SORPTION AND MIGRATION OF RADIOACTIVE ELEMENTS IN SOILS. V. Spitsin, V. C. Balukova, and T. A. Ermanova. p.569-77 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In Russian)

The results are presented of investigations into the sorption and migration of radioelements during radioactive filtering flow through the soil. The types of sand, of average coarseness and effective porosity, which are to be found widely disseminated throughout the central belt of the Soviet Union were used. It is shown that the sorption of strontium and cesium take place separately and that the capture of cesium by soils is an irreversible process. It is also shown that sorption processes inhibit the filter-diffusion process at low diffusion rates and that the strontium movement is 40 to 60 times slower than the filtering and the cesium movement 100 times slower. Trials were made with a method of calculating the basic kinetic parameters of sorption, thus making it possible to characterize the movement of radioactive strontium and describe the migration of radioactive cesium. (auth)

**33410** TREATMENT AND PACKAGING OF SOLID WASTE IRRADIATED IN PILE. P. Cerré, E. Mestre, and P. Lebrun (CEN, Saclay, France). p.599-621 of "Treatment and Storage of High-Level Radioactive Wastes." Vienna, International Atomic Energy Agency, 1963. (In French)

The solid waste produced in atomic centers varies greatly in nature, form, and activity, ranging from weakly contaminated laboratory waste to unwieldy devices irradiated in the reactor and highly radioactive. Methods of treatment, packaging, and protection in respect of these types of waste are described. In particular, the paper describes a pilot unit which was operated at Saclay for eighteen months and which led to the construction of a remote-controlled plant for treating and packaging all kinds of solid wastes, whatever their activity and shape. (auth)

**33411** SPRAY CALCINATION REACTOR. Benjamin M. Johnson (to U. S. Atomic Energy Commission). U. S. Patent 3,101,258. Aug. 20, 1963.

A spray calcination reactor for calcining reprocessing waste solutions is described. Coaxial within the outer shell of the reactor is a shorter inner shell having heated walls and with open regions above and below. When the solution is sprayed into the inner shell droplets are entrained by a current of gas that moves downwardly within the inner shell and upwardly between it and the outer shell, and while thus being circulated the droplets are calcined to solids, which drop to the bottom without being deposited on the walls. (AEC)

# CORPORATE AUTHOR INDEX

This index contains entries for all report literature and, in addition, for certain published literature items for which it is felt that a corporate approach is especially desirable, e.g., symposia, conference proceedings, and meetings.

Each entry under a corporate author is a shortened version of the title of the publication, followed by the *NSA* volume and abstract number. Report numbers are given in parentheses.

The phrase "Progress report" is abbreviated as "Prog. rpt.," permitting a more rapid and complete alphabetical arrangement of the titles without changing the location of the progress report titles in relation to the other titles.


## A

**ACADEMIA R. P. R. INSTITUTUL DE FIZICĂ ATOMICĂ, BUCHAREST.**
Thermal neutron activation of natural isotopes, 17: 32709 (IFA/SN/17)

**ADVANCED TECHNOLOGY LABS. DIV. OF AMERICAN-STANDARD, MOUNTAIN VIEW, CALIF.**
Prog. rpt. on thermal-stress-fatigue of stainless steels, 4–6/63, 17: 32566 (ATL-A-137)

**AEROJET-GENERAL NUCLEONICS, SAN RAMON, CALIF.**
ML-1 reactor stability tests, 17: 33302 (AGN-TM-403)
Mobile GCR, 17: 33313 (IDO-28584(Add.1))

**AKADEMIYA NAUK S.S.S.R.**
Calculations of nuclear fission according to liquid drop model, 17: 33009 (UCRL-Trans-978)

**AKTIEBOLAGET ATOMENERGI, STOCKHOLM.**
Absolute disintegration rate of Cs-137 sources, 17: 32319 (AE-112)
Bibliography on uranates and related U compounds, 17: 32049 (VDIT-77)
Burnout conditions for flow of boiling water in vertical round ducts, 17: 32242 (AE-113)
Burnout conditions for flow of boiling water in vertical round ducts. II., 17: 32243 (AE-114)
Calculations of optimum material distributions, 17: 33237 (AE-110)
Paramagnetism of Mn dissolved in Cu–Al and Cu–Ge alloys, 17: 32561 (AE-111)

**ALLIS-CHALMERS MFG. CO., MILWAUKEE.**
Prog. rpt. on shaped burnable poison, 3–6/63, 17: 33236 (ACNP-63022)
Prog. rpt. on steam separation technology, 4–6/63, 17: 32206 (ACNP-63021)
Prog. rpt. on vapor volume fraction and slip velocity, 4/15–6/30/63, 17: 32241 (ACNP-63020)

**AMES LAB., AMES, IOWA.**
Process simulation on digital computer, 17: 32474 (IS–698)

**AMF ATOMICS. DIV. OF AMERICAN MACHINE AND FOUNDRY CO., GREENWICH, CONN.**
Hazards report for APTR critical experiment, 17: 33373 (NP-12998)

**ARGONNE NATIONAL LAB., ILL.**
Application of NMR to transition metals, 17: 32569 (CONF-54-1)
Cross section of Cu-63 for nuclear accident dosimetry, 17: 33000 (CONF-67-15)
Fast neutron scattering from Ta-181, 17: 32991 (ANL-6727)
Graphical method in the analysis of $SU_3$, 17: 32896 (ANL-6729)

**ARIZONA STATE UNIV., TEMPE.**
Colloid absorption band in CsBr, 17: 32043 (TID-19124)

**ARNOLD ENGINEERING DEVELOPMENT CENTER, ARNOLD AF STATION, TENN.**
Simulation of high-energy penetrating radiations, 17: 32884 (AEDC-TDR-63-118)

**ASSOCIATION TECHNIQUE POUR L'ENERGIE NUCLÉAIRE, PARIS.**
Conference on nuclear technology, Tokyo, 11/62, 17: 33267

**ATOMIC ENERGY OF CANADA LTD., CHALK RIVER, ONT.**
Manual of low-activity environmental analyses, 17: 32282 (AECL-1745)
Stainless steel-sheathed $UO_2$ fuel elements, 17: 32662 (CRFD-1132)
Thermal conductivity of $UO_2$ under irradiation, 17: 32661 (CRDC-1143)

**ATOMIC ENERGY OF CANADA LTD. CHALK RIVER NUCLEAR LABS., CHALK RIVER, ONT.**
Electronics, 17: 32726 (PR-P-57(p.44-68))
General physics, 17: 32724 (PR-P-57(p.21-36))
Kinetic energy and fine structure in spontaneous fission of Cf-252, 17: 32995 (CONF-46-44)
Neutron physics, 17: 32725 (PR-P-57(p.37-43))
Nuclear physics, 17: 32723 (PR-P-57(p.5-20))
Prog. rpt. on physics, 1–3/63, 17: 32722 (PR-P-57)
Theoretical physics, 17: 32727 (PR-P-57(p.69-85))

**ATOMICS INTERNATIONAL. DIV. OF NORTH AMERICAN AVIATION, INC., CANOGA PARK, CALIF.**
Prog. rpt. on Hg-lubricated journal bearings, 10–12/62, 17: 32249 (SY-5455-R)
Superconductivity and localized magnetic states in Ti–Mn alloys, 17: 32706 (CONF-23-19)
Tritium $\beta$-decay induced reactions in polystyrene fluff, 17: 32152 (CONF-14-21)

**AUSTRALIA. ATOMIC ENERGY COMMISSION RESEARCH ESTABLISHMENT, LUCAS HEIGHTS, NEW SOUTH WALES.**
Bibliography on binary and ternary systems with BeO, 17: 32560 (AAEC/TM-199)
Prestressed concrete pressure vessels for reactors, 17: 33235 (AAEC/TM-198)

**AVCO CORP. AVCO-EVERETT RESEARCH LAB., EVERETT, MASS.**
Kramers' and line radiation from $N_2$ and air shocks, 17: 32705 (BSD-TDR-63-102)

## B

**BARTOL RESEARCH FOUNDATION, SWARTHMORE, PENNA.**
High angular momentum cut-off in nuclear level densities, 17: 32999 (CONF-62-7)

**BATTELLE MEMORIAL INST., COLUMBUS, OHIO.**
Creep and tensile properties of Nb-base alloys, 17: 32568 (CONF-53-5)
Prog. rpt. on UN, 10–21/62, 17: 32483 (BMI-X-10027)
Properties of F-48 Nb alloy, 17: 32567 (BMI-X-249)
Radiation stability of UN, 17: 32660 (BMI-1638)
Stability of molten U and refractory carbides, 17: 32036 (CONF-40-2)

**BATTELLE MEMORIAL INST. DEFENSE METALS INFORMATION CENTER, COLUMBUS, OHIO.**
Large-size furnaces for heat treating metal assemblies, 17: 32207 (DMIC-Memo-167)

**BOEING CO., SEATTLE.**
Interaction of moving source currents with hydromagnetic fluid,

17: 32708 (D1-82-0254)
Long wavelength charge oscillations of cylindrical plasma, 17: 33144 (D1-82-0255)
Mass distribution and throwout studies, Project Sedan, 17: 31802 (PNE-217F)
Stability of positive column in time dependent magnetic field, 17: 33142 (D1-82-0218)
Thermal cutoffs of whistler mode of propagation, 17: 33143 (D1-82-0229)

**BROOKHAVEN NATIONAL LAB., UPTON, N. Y.**
Chemistry and chemical engineering, 17: 31795 (BNL-782(p.18-43))
Energy-dependent Milne problem with simple scattering kernel, 17: 32969 (BNL-6949)
Engineering, 17: 31799 (BNL-782(p.92-4))
Flying spot film measuring employing crossed glass fibers, 17: 32332 (BNL-6878)
Hot laboratory, 17: 31797 (BNL-782(p.51-9))
Illumination of 80-in. bubble chamber, 17: 32397 (BNL-6848)
*In vivo* activation in mice of C-12, N-14, and O-16, 17: 31851 (BNL-6989)
$K^-$-p total cross section between 2.7 and 5.2 Bev/c, 17: 32897 (BNL-6962)
Lymphocyte production measured by extracorporeal irradiation, 17: 31852 (BNL-7137)
Metallurgy, 17: 31798 (BNL-782(p.60-91))
Optical model neutron transmission coefficients, 17: 32968 (BNL-765)
Prog. rpt. on nuclear engineering, 9–12/62, 17: 31793 (BNL-782)
Properties of quadrupole magnet doublets, 17: 32703 (BNL-795)
Radiation, 17: 31796 (BNL-782(p.44-50))
Reactor physics, 17: 31794 (BNL-782(p.1-17))
Resonance production in $^{83}Kr$ final state, 17: 32898 (BNL-7105)
Scattering of He-3 by $\alpha$ particles, 17: 32993 (BNL-6955)
Theory of electron emission widths, 17: 32704 (BNL-6916)
Velocity polynomials in neutron thermalization, 17: 32973 (CONF-39-46)

**BUREAU OF MINES, BERKELEY, CALIF.**
Heat capacities of sesquioxides of Sc and Ce, 17: 32031 (BM-RI-6245)

## C

**CALIFORNIA INST. OF TECH., PASADENA.**
Prog. rpt. on dislocation mobility and density of metallic crystals, 7/63, 17: 32575 (TID-19181)

**CALIFORNIA. UNIV., BERKELEY. LAWRENCE RADIATION LAB.**
Baryon spectroscopy, 17: 32918 (UCRL-10897)
Bevatron external proton beam, 17: 33122 (UCRL-10868)
Bevatron improvements, 17: 33120 (UCRL-10866)
High-intensity phenomena at the Bevatron, 17: 33121 (UCRL-10867)
High-temperature chemistry under-developed areas, 17: 31981 (UCRL-10882)
Instability in three-phase magnetic amplifier operation, 17: 32342 (UCRL-10855)
Instability of alternating-current positive column in magnetic field, 17: 33161 (UCRL-10698)
Kinetic energy and fine structure in spontaneous fission of Cf-252, 17: 32995 (CONF-46-44)
Multiparameter pulse-height recording system, 17: 32343 (UCRL-10874)
Properties of F-48 Nb alloy, 17: 32567 (BMI-X-249)
Substructure of plastically deformed nickel, 17: 32576 (UCRL-10778)
Terrestrial gamma radioactivity, 17: 32264 (UCRL-10636)
UNFOLD—program for analyzing linear systems, 17: 32476 (UCRL-10927)

**CALIFORNIA. UNIV., DAVIS.**
Cardiovascular disease in irradiated beagles, 17: 31862 (UCD-107 (p.50-73))
Dyadic dominance-submission patterns in female beagle, 17: 31864 (UCD-107(p.86-97))
Examination of control and x-irradiated beagles, 17: 31859 (UCD-107 (p.13-29))
Experimental dog survival, 17: 31868 (UCD-107(p.275-81))
Kennel management and clinical observations, 17: 31858 (UCD-107 (p.7-12))
Mammary tumors in x-irradiated and control beagles, 17: 31860 (UCD-107 (p.30-43))
Ophthalmoscopic findings in experimental beagles, 17: 31861 (UCD-107 (p.44-9))
Pathology report on beagles, 17: 31867 (UCD-107(p.129-274))
Prog. rpt. on irradiated beagles, annual, 6/63, 17: 31857 (UCD-107)
Psychological field research program, 17: 31863 (UCD-107(p.74-85))
Radiation effects on beagle reproduction. I., 17: 31865 (UCD-107(p.98-111))
Radiation effects on beagle reproduction. II., 17: 31866 (UCD-107 (p.112-28))

**CALIFORNIA. UNIV., LIVERMORE. LAWRENCE RADIATION LAB.**
Electric quadrupole moment of Te-125, 17: 33007 (UCRL-7297)
Electrode sheath effects in pulsed, high-current discharges, 17: 32734 (UCRL-7357)
Electrons trapped in the earth's magnetic field following nuclear bursts, 17: 32845 (UCRL-7309(Rev.I))
High-current linear induction accelerator for electrons, 17: 33119 (UCRL-7408)
Initial-fields specification problem, 17: 32846 (UCRL-13084)
Mass motion of high-altitude nuclear explosion, 17: 31803 (UCRL-7224 (Rev.II))
Methods of handling and laundering Be-contaminated garments, 17: 32281 (UCRL-7311)
Production of transuranium elements in a thermonuclear explosion—Anacostia, 17: 32733 (UCRL-7314(Rev.I))
Scattering of 14-mev neutrons from N and O, 17: 33006 (UCRL-7192)
Spark chamber as detector of fission fragments, 17: 32403 (UCRL-7169)

**CALIFORNIA. UNIV., LOS ANGELES.**
Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)

**CAROLINAS VIRGINIA NUCLEAR POWER ASSOCIATES, INC., PARR, S. C.**
Digital computer program for thermodynamic properties of $D_2O$, 17: 32283 (CVNA-129)

**CENTRO INFORMAZIONI STUDI ESPERIENZE, MILAN.**
Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)
Critical heat flux data for flow of steam–water mixtures, 17: 32245 (EURAEC-671)

**CHICAGO. UNIV.**
Outlook in hypernuclear physics, 17: 32901 (EFINS-63-32)
Strong and weak interactions of bound $\Lambda$ particles, 17: 32900 (EFINS-63-29)
Structure of weak interaction $\Lambda + N \rightarrow N + N$, 17: 32903 (EFINS-63-39)

**CHICAGO. UNIV. ENRICO FERMI INST. FOR NUCLEAR STUDIES.**
Outlook in hypernuclear physics, 17: 32901 (EFINS-63-32)
Strong and weak interactions of bound $\Lambda$ particles, 17: 32900 (EFINS-63-29)
Structure of weak interaction $\Lambda + N \rightarrow N + N$, 17: 32903 (EFINS-63-39)
Uniqueness of partial wave amplitudes, 17: 32904 (EFINS-63-40)
Vector mesons as Regge poles in perturbation theory, 17: 32902 (EFINS-63-35)

**COLUMBIA UNIV., IRVINGTON-ON-HUDSON, N. Y. NEVIS LABS.**
Muon capture in H, 17: 33002 (NEVIS-116)
Muonic molecules in liquid H, 17: 33003 (NEVIS-117)

**COLUMBIA UNIV., NEW YORK.**
Linear amplifier for high counting rates, 17: 32334 (CONF-58-4)

**COMBUSTION ENGINEERING, INC., WINDSOR, CONN.**
PL condenser evaluation report, 17: 33303 (CEND-139)

## D

**DEUTSCHES ELEKTRONEN-SYNCHROTRON, HAMBURG.**
Photomultipliers with optical impulses, 17: 32335 (DESY-A2.99)

**DIVISION OF ISOTOPES DEVELOPMENT, AEC.**
Radioisotope application to coal, 17: 32320 (CONF-124-2)

**DIVISION OF REACTOR DEVELOPMENT, AEC.**
Objectives and plans for AEC's civilian power GCR program, 17: 33304 (CONF-39-33)

**DOW CHEMICAL CO. ROCKY FLATS DIV., GOLDEN, COLO.**
Corrosion studies on stainless steel containing B-10, 17: 32517 (RFP-307)

**DU PONT DE NEMOURS (E. I.) & CO. SAVANNAH RIVER LAB., AIKEN, S. C.**

Extraction behavior of Zr, 17: 32191 (DP-818)
Prog. rpt. on processing reactor fuels, 1–3/63, 17: 32192 (DP-839)
Solvent extraction data for Pu, 17: 32190 (DP-700)
**DU PONT DE NEMOURS (E. I.) & CO. SAVANNAH RIVER PLANT, AIKEN, S. C.**
Monitoring, decontamination, and bio-assay of Pu-contaminated injury, 17: 31962 (DPSPU-63-30-5)
Radioiodine release incident, 17: 32284 (DPSPU-63-30-26B)
Stress corrosion cracking of Type 304 stainless steel, 17: 32516 (DPSPU-62-30-26)
**DUBLIN INST. FOR ADVANCED STUDIES.**
Hermiticity of Hamiltonians and existence of eigenstates in soluble field theories, 17: 32720 (NP-13004)
**DUKE UNIV., DURHAM, N. C.**
Energy levels in square well with hard core, 17: 33001 (CONF-128-1)
**DUQUESNE LIGHT CO., SHIPPINGPORT, PENNA.**
Radiation survey of reactor vessel head, 17: 33306 (DLCS-3050123)

## E

**EUROPEAN ATOMIC ENERGY COMMUNITY.**
Irradiation facilities in Ispra I reactor, 17: 33365 (EUR-374.e)
Reactivity effects due to variations in nuclear parameters, 17: 33307 (EUR-281.e)
**EUROPEAN ATOMIC ENERGY COMMUNITY. NUCLEAR RESEARCH CENTER, ISPRA, ITALY.**
Irradiation facilities in Ispra I reactor, 17: 33365 (EUR-374.e)
Reactivity effects due to variations in nuclear parameters, 17: 33307 (EUR-281.e)

## F

**FLORIDA STATE UNIV., TALLAHASSEE.**
Scattering of He-3 by $\alpha$ particles, 17: 32993 (BNL-6955)
**FRANCE. COMMISSARIAT À L'ÉNERGIE ATOMIQUE. CENTRE D'ÉTUDES NUCLÉAIRES, SACLAY.**
Generation of pseudo-random gating impulse, 17: 32344 (AEC-tr-5901)
Measurement of activity of $\beta$-emitting gases using 367 ionization chambers, 17: 32398 (CEA-2215)
**FRANCE. SERVICE CENTRAL DE PROTECTION CONTRE LES RAYONNEMENTS IONISANTS, PARIS.**
Prog. rpt. on health and safety, 4/63, 17: 32289 (SCPRI(RM)V-1963)

## G

**GARRETT CORP. AIRESEARCH MFG. DIV. OF ARIZONA, PHOENIX.**
Prog. rpt. on Hg-lubricated journal bearings, 10–12/62, 17: 32249 (SY-5455-R)
**GENERAL ATOMIC DIV., GENERAL DYNAMICS CORP., SAN DIEGO, CALIF.**
Development of BeO for EBOR, 17: 33366 (GA-4333)
Neutron thermalization in ZrH, 17: 32974 (GA-4328)
Prog. rpt. on gas-cooled reactor, 10–12/62, 17: 33308 (GA-4247)
Thermal stability studies of graphite–matrix fuel systems, 17: 32570 (GA-2880)
**GENERAL DYNAMICS/CONVAIR, SAN DIEGO, CALIF.**
Prog. rpt. on radiation-resistant pneumatic power systems, 17: 32208 (GDC-63-140)
**GENERAL ELECTRIC CO. ADVANCED TECHNOLOGY SERVICES, CINCINNATI.**
Prog. rpt. on maritime nuclear steam generator, 12/31/62–5/15/63, 17: 33312 (GEMP-215)
Rare earth borates, 17: 32035 (CONF-20-28)
Thorium oxide—diffusion of oxygen in, compatibility with borides, and coating borides, 17: 32564 (ASD-TDR-63-635)
**GENERAL ELECTRIC CO. ATOMIC POWER EQUIPMENT DEPT., SAN JOSE, CALIF.**
Coextruded stainless steel-clad $UO_2$ fuel rods, 17: 32536 (GEAP-4282)
Failures of $UO_2$ swaged fuel rod, 17: 32664 (GEAP-4197)
Prog. rpt. on EVESR superheat fuel, 12/62–2/63, 17: 33309 (GEAP-4200)
Prog. rpt. on EVESR superheat fuel, 3–5/63, 17: 33310 (GEAP-4277)
Prog. rpt. on Garigliano reactor, 7/63, 17: 33311 (GEAP-4306)
Prog. rpt. on transition boiling heat transfer, 4–6/63, 17: 32247 (GEAP-4307)
Prog. rpt. on two-phase flow, 4–6/63, 17: 32246 (GEAP-4251)
Superheat fuel design, 17: 33239 (GEAP-4244)
**GENERAL ELECTRIC CO. HANFORD ATOMIC PRODUCTS OPERATION, RICHLAND, WASH.**
Burnup data from PRTR Pu–Al fuel element, 17: 32666 (HW-77935)
Effect of massive neutron exposure on reactor graphite, 17: 32667 (HW-SA-2926)
Effects of cold work and neutron irradiation on Zy-2, 17: 32665 (HW-74955)
Fission product confinement for NPR, 17: 33363 (HW-SA-2891(Rev.))
Fission product release from PRTR rupture, 17: 33369 (HW-75045)
Gamma spectrometry using $\beta$–$\gamma$ coincidence, 17: 32399 (HW-SA-2932)
Hanford Pu fuel development laboratory, 17: 32537 (HW-SA-2904)
Idealized Pu dissolvers, 17: 32895 (HW-SA-2999)
Inorganic ion exchange separation of Cs, 17: 33396 (HW-SA-2920)
Nut-clamp seating geometries in connector couplings for NPR, 17: 33362 (HW-71229)
Physical Constants Testing Reactor manual, 17: 33367 (HW-69714)
Primary coolant pump for PRTR, 17: 33370 (HW-SA-3098)
Program HACK—correction to sensor activity for decay and burnup, 17: 33241 (HW-78131)
Protective clothing monitoring system, 17: 32286 (HW-76351)
Radioactive waste fractionization and packaging, 17: 33395 (HW-SA-2786)
Surge suppressors for PRTR process tube meters, 17: 33368 (HW-70711 (Rev.))
Ultrasonics in fatigue testing, 17: 32262 (HW-SA-2927)
Welding of stainless steel, 17: 32540 (TID-19161)
**GENERAL ELECTRIC CO. VALLECITOS ATOMIC LAB., PLEASANTON, CALIF.**
Theory of pulsed neutron source measurements, 17: 32894 (CONF-39-47)
**GENERAL ELECTRIC CO. VALLECITOS ATOMIC LAB., SAN JOSE, CALIF.**
Post-irradiation examination of $PuO_2$–$UO_2$ fuel, 17: 32663 (GEAP-3833)
Prog. rpt. on Pu-recycle, 4–6/63, 17: 33240 (GEAP-4303)
Prog. rpt. on Zr alloy design, 4–6/63, 17: 32484 (GEAP-4284)
**GENERAL NUCLEAR ENGINEERING CORP., DUNEDIN, FLA.**
Power Reactor Technology, Vol. 6, No. 3, 6/63, 17: 33361
**GENERAL TELEPHONE AND ELECTRONICS LABS. INC., BAYSIDE, N. Y.**
Prog. rpt. on direct conversion of $UF_4$ to UC, final, 7/61–6/62, 17: 32182 (GTR-17)
**GEORGIA INST. OF TECH., ATLANTA.**
Production of slow electrons and positive ions in He, Ne, Ar, $H_2$, $N_2$, $O_2$ and CO by helium ions, 17: 32731 (TID-19137)
**GEORGIA INST. OF TECH., ATLANTA. ENGINEERING EXPERIMENT STATION.**
Prog. rpt. on materials for nuclear engineering applications, 7/62–6/63, 17: 32488 (TID-19057)
**GERMANY. ZENTRALINSTITUT FUR KERNPHYSIK, DRESDEN.**
Building of color centers in ion crystals by x irradiation, 17: 32671 (ZFK-WF-22)
Decay of Tm-168, 17: 33008 (ZFK-PHA-8)
Electron microscopy of irradiated sintered $UO_2$ pellets, 17: 32670 (ZFK-WF-21)
Lithium-glass scintillators for detection of neutrons, 17: 32405 (ZFK-RN-19)

## H

**HARVARD UNIV., CAMBRIDGE, MASS.**
Geometry of $Li_2O$ by electric deflection, 17: 32030 (AROD-006.9)
Magnetic resonance studies of unpaired atoms in solid $D_2$, 17: 32042 (TID-19123)
Radiation from electromagnetic source in half-space of compressible plasma-surface waves, 17: 33141 (AD-410077)
**HONEYWELL RESEARCH CENTER, HOPKINS, MINN.**
Infrared modulation by free carrier absorption, 17: 32729 (SCR-636)
**HUGHES RESEARCH LABS. DIV. OF HUGHES AIRCRAFT CO., MALIBU, CALIF.**

Prog. rpt. on $H_2$ dissociation, 5/15–8/14/63, 17: 32732 (TID-19169)

## I

**IBM NETHERLANDS, AMSTERDAM.**
STRZ—program for steady-state temperature distribution, 17: 32248 (RCN-16)
**ILLINOIS INST. OF TECH., CHICAGO. IIT RESEARCH INST.**
Prog. rpt. on wave propagation under anomalous conditions, 12/15/62–3/15/63, 17: 32844 (ARF-A218-12)
**ILLINOIS. UNIV., URBANA. ENGINEERING EXPERIMENT STATION.**
Bubble motion in turbulent liquid stream, 17: 32250 (TID-19224)
**INDIA. ATOMIC ENERGY ESTABLISHMENT, TROMBAY.**
Active particles in fallout from weapon tests, 17: 32283 (AEET/AM/34)
Electrical properties of alpha–$U_3O_8$, 17: 32562 (AEET/CD/13)
**INTERNATIONAL ATOMIC ENERGY AGENCY, VIENNA.**
Conference on radioactive wastes, Vienna, 10/62, 17: 33398
**INTERNATIONAL PIPE AND CERAMICS CORP., LOS ANGELES.**
Fabrication of thin $UO_2$ plates, 17: 32534 (CONF-50-3)
**ITALY. COMITATO NAZIONALE PER L'ENERGIA NUCLEARE, ROME.**
Amplifier for neutron thermopile or thermocouple, 17: 32339 (RT/EL(63)3)
**ITALY. COMITATO NAZIONALE PER L'ENERGIA NUCLEARE. LABORATORI NAZIONALI, FRASCATI.**
Circuit to measure maximum energy of bremsstrahlung, 17: 32401 (LNF-63/17)
Cross section for production of pairs from photons in crystals, 17: 32711 (LNF-62/113)
Linear theory of accelerators. II., 17: 33117 (LNF-63/18)
Production of electron pairs in thick converters, 17: 32713 (LNF-63/27)
Superconducting magnets, 17: 32712 (LNF-63/26)
73.6-MHz radiofrequency installation for AdA, 17: 33116 (LNF-63/10)
**ITALY. ISTITUTO SUPERIORE DI SANITÀ, ROME.**
Circuit diagrams and electronic equipment, 17: 32336 (ISS-63/25)

## J

**JAPAN ATOMIC INDUSTRIAL FORUM, INC., TOKYO.**
Conference on nuclear technology, Tokyo, 11/62, 17: 33267
**JOINT INST. FOR NUCLEAR RESEARCH, DUBNA, U.S.S.R.**
Separation of rare-earth elements by electrophoresis, 17: 32196 (UCRL-Trans-973)

## K

**KENTUCKY. UNIV., LEXINGTON.**
Neutron activation determination of Zr and Hf, 17: 31986 (TID-19179)
**KERNFORSCHUNGSANLAGE, JÜLICH, GERMANY.**
Reproducibility of light emission from sliding spark gap in high vacuum, 17: 32710 (JUL-123-PP)
Water discharge measurement in compact core of FRJ-1, 17: 33372 (JUL-125-RE)
**KERNFORSCHUNGSZENTRUM, KARLSRUHE, GERMANY.**
Bibliography on Au-198 in medicine, 17: 31814 (KFK-143)
Doppler coefficients of fast reactors, 17: 33242 (KFK-153)
Polarimeter for study of $\gamma$–$\gamma$ cascades, 17: 32400 (KFK-129)
**KNOLLS ATOMIC POWER LAB., SCHENECTADY, N. Y.**
Asymptotic neutron spectra in multiplying media, 17: 32971 (CONF-11-6)

## L

**LITTLE (ARTHUR D.) INC., CAMBRIDGE, MASS.**
Geometry of $Li_2O$ by electric deflection, 17: 32030 (AROD-006.9)
**LOCKHEED MISSILES & SPACE CO., SUNNYVALE, CALIF.**
Bibliography on composite materials. Suppl. I., 17: 32482 (AD-408618)
Bibliography on microminiaturization, 17: 32338 (NP-12989)
Bibliography on weld properties, 17: 32533 (AD-409795)
**LOS ALAMOS SCIENTIFIC LAB., N. MEX.**
Detonation properties of condensed explosives, 17: 32039 (LA-2900)
Electronic processing and analysis of metabolic data, 17: 31815 (LADC-5627)
Excitation of $N_2^+$ first negative system in bombardment of $N_2$ by $N_2^+$, 17: 32707 (CONF-46-43)
Genetic effects of x irradiation of male mice, 17: 31853 (LADC-5618)
Half-lives of Cs-137 and Co-60, 17: 32719 (NP-12996(p.38-42))
Measuring radioactive dusts, 17: 32310
$\nu_3$ and $\nu_1$ bands of the $NT_3$ molecule, 17: 32048 (TID-19213)
Prog. rpt. on UHTREX, 6/20/63, 17: 33314 (LAMS-2933)
Respirator program for U mills, 17: 32311
**LOVELACE FOUNDATION FOR MEDICAL EDUCATION AND RESEARCH, ALBUQUERQUE, N. MEX.**
Fission products released from irradiated U when heated in air. I., 17: 32287 (LF-9)

## M

**MANLABS, INC., CAMBRIDGE, MASS.**
Substructure and mechanical properties of refractory metals, 17: 32565 (ASD-TR-61-181(Pt.III))
**MARYLAND. UNIV., COLLEGE PARK.**
Mixing of T = 0 and T = 1 states in giant resonance region of O-16, 17: 33004 (NP-12986)
Triton-induced reactions on B-10, 17: 32997 (CONF-46-79)
**MASSACHUSETTS INST. OF TECH., CAMBRIDGE.**
Conference on photon interactions in Bev-energy range, Cambridge, Mass., 1/63, 17: 32908 (TID-7668)
Crystal and molecular structure of bis(dipivaloylmethanido)zinc(II), 17: 32040 (NYO-10552)
Experiments in progress at CEA, 17: 32916 (TID-7668(Sect.VIII))
New detection methods [photon interactions], 17: 32915 (TID-7668(Sect. VII))
New electron accelerators, 17: 32917 (TID-7668(Sect.IX))
New experimental approaches [photon interactions], 17: 32914 (TID-7668 (Sect.VI))
Photoproduction, experimental, 17: 32912 (TID-7668(Sect.IV))
Photoproduction, theory, 17: 32913 (TID-7668(Sect.V))
Quantum electrodynamics and electromagnetic form factors, 17: 32909 (TID-7668(Sect.I))
Regge poles. I., 17: 32910 (TID-7668(Sect.II))
Regge poles. II., 17: 32911 (TID-7668(Sect.III))
**METEOROLOGY INTERNATIONAL INC., MONTEREY, CALIF.**
Initial-fields specification problem, 17: 32846 (UCRL-13084)
**MICHIGAN. UNIV., ANN ARBOR.**
Density measurement applied to alkali metal vapors oriented by optical pumping, 17: 32047 (TID-19198)
Elastic scattering of negative pions by protons, 17: 32906 (NP-12990)
**MIDWESTERN UNIVERSITIES RESEARCH ASSN., MADISON, WIS.**
Accelerator as pion factory, 17: 33114 (CONF-125-4)
Betatron oscillation frequencies in spiral sector FFAG accelerator, 17: 33111 (CONF-125-1)
Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)
Proton linear accelerators for energies up to 300 Mev, 17: 33113 (CONF-125-3)
Spiral-sector FFAG magnet design, 17: 33115 (CONF-125-5)
**MOUND LAB., MIAMISBURG, OHIO.**
Gaseous thermal diffusion separation systems, 17: 32467 (CONF-8-5)
**MSA RESEARCH CORP., CALLERY, PENNA.**
Prog. rpt. on effect of 1200°F Na on steels, 6/63, 17: 32571 (MSAR-63-105)
**MUNICH. UNIVERSITÄT.**
Systems $Eu_2O_3$–$UO_2$ and $PuO_2$–$Eu_2O_3$, 17: 32572 (NP-13003)

## N

**NATIONAL AERONAUTICS AND SPACE ADMINISTRATION. LEWIS RESEARCH CENTER, CLEVELAND.**
Resonance in cold multiconstituent plasma at arbitrary orientation to magnetic field, 17: 33148 (NASA-TN-D-1875)
**NATIONAL BUREAU OF STANDARDS, BOULDER, COLO.**
Prog. rpt. on cryogenic aspects of Project Sherwood, 4–6/63, 17: 33149 (NBS-7919)
**NATIONAL BUREAU OF STANDARDS, WASHINGTON, D. C.**
Vaporization of Pr–Group V compounds, 17: 32033 (CONF-20-5)
**NATIONAL RESEARCH COUNCIL. COMMITTEE ON NUCLEAR SCIENCE.**
Distillation techniques for radiochemical separations, 17: 32154 (NAS-

NS-3108)
**NATIONAL RESEARCH COUNCIL. MATERIALS ADVISORY BOARD.**
Beryllium in aerospace structures, 17: 32485 (MAB-193-M)
**NAVAL RESEARCH LAB., WASHINGTON, D. C.**
Baryon doublets and neutrino doublets. II., 17: 32716 (NP-12996(p.23-8))
Half-lives of Cs-137 and Co-60, 17: 32719 (NP-12996(p.38-42))
Nuclear and cosmic radiation in ocean, 17: 32718 (NP-12996(p.36-7))
Prog. rpt. on nuclear science, 10–12/62, 17: 32714 (NP-12996)
Quaternion approach to elementary particle theory. II., 17: 32715 (NP-12996(p.1-22))
Triton-induced reactions on B-10, 17: 32997 (CONF-46-79)
Unitary operators in quantum field theory, 17: 32717 (NP-12996(p.29-35))
**NEW MEXICO. UNIV., ALBUQUERQUE.**
Spectra and decay times of luminescences from chelated rare earth ions, 17: 31980 (CONF-37-4)
**NEW YORK OPERATIONS OFFICE. HEALTH AND SAFETY LAB., AEC.**
Fallout protection in structures, 17: 31804 (WT-1462)
**NEW YORK UNIV., NEW YORK.**
Prog. rpt. on environmental radiation 6/63, 17: 32290 (TID-19111)
**NEW YORK UNIV., NEW YORK. ATOMIC ENERGY COMMISSION COMPUTING AND APPLIED MATHEMATICS CENTER.**
Calculating ground-state properties of many-particle systems, 17: 33227 (NYO-10431)
Calculations of electronic wave functions of diatomic molecules, 17: 32721 (NYO-10423)
Development and use of methods of LR type, 17: 33226 (NYO-10429)
**NEW ZEALAND. DOMINION X-RAY AND RADIUM LAB., CHRISTCHURCH.**
Prog. rpt. on fallout in New Zealand, 1–3/63, 17: 32285 (DXRL-F8)
**NORTH CAROLINA STATE COLL., RALEIGH.**
Prog. rpt. on nuclear fuel, 6/63, 17: 32487 (NCSC-2981-4)
Prog. rpt. on radiation and radiological protection, final, 6/9/62–5/30/63, 17: 31855 (TID-19126)
Prog. rpt. on U interstitial phases, 6/63, 17: 32486 (NCSC-2663-13)
**NORTH CAROLINA. UNIV., CHAPEL HILL.**
Energy levels in square well with hard core, 17: 33001 (CONF-128-1)
Prog. rpt. on marine invertebrate infauna distribution, final, 17: 31817 (TID-19122)
Prog. rpt. on radiation and radiological protection, final, 6/9/62–5/30/63, 17: 31855 (TID-19126)
**NORTHWESTERN UNIV., EVANSTON, ILL.**
Structure of weak interaction $\Lambda \to N \to N + N$, 17: 32903 (EFINS-63-39)
**NUCLEAR METALS, INC., CONCORD, MASS.**
Prog. rpt. on $\beta$ treatment of U, 11/59–8/60, 17: 32538 (NMI-2801)
Prog. rpt. on $\beta$ treatment of U, 8–11/61, 17: 32539 (NMI-2805)
**NUCLEAR SCIENCE AND ENGINEERING CORP., PITTSBURGH.**
Analysis and evaluation of fallout radioactivity, 17: 32288 (NSEC-91)

# O

**OAK RIDGE GASEOUS DIFFUSION PLANT, TENN.**
Electro-pneumatic constant volume manometer, 17: 32337 (K-1577)
Separation of multicomponent mixtures having small separation factors, 17: 32468 (TID-18966)
**OAK RIDGE NATIONAL LAB., TENN.**
Clad fuel development, 17: 33323 (ORNL-3445(p.199-217))
Component development and testing for EGCR, 17: 33318 (ORNL-3445 (p.30-6))
Cross sections, 17: 33155 (ORNL-3472(p.56-69))
DCX-1 plasma experiments, 17: 33151 (ORNL-3472(p.1-8))
DCX-2, 17: 33152 (ORNL-3472(p.9-23))
Development of fueled-graphite bodies, 17: 33321 (ORNL-3445(p.111-37))
Dislocation movement in sintering of $CaF_2$, 17: 32037 (CONF-50-14)
Emission spectra of electron-irradiated metal foils, 17: 32669 (ORNL-3450)
Facilities and equipment for GCR, 17: 33327 (ORNL-3445(p.329-46))
Fission-product transport and deposition from gas streams, 17: 33243 (ORNL-3379)
Fueled-graphite systems, 17: 33322 (ORNL-3445(p.138-98))
GCR advance systems, 17: 33325 (ORNL-3445(p.251-97))
Heat transfer and fluid flow, 17: 33326 (ORNL-3445(p.298-328))
High-density slag concrete, 17: 33222 (ORNL-3473)
Irradiation testing of GCR components and materials, 17: 33320 (ORNL-3445(p.63-108))
Magnetics and superconductivity, 17: 33158 (ORNL-3472(p.84-106))
Material transport during sintering of fluorite structure materials, 17: 32535 (CONF-50-15)
Materials development for EGCR, 17: 33319 (ORNL-3445(p.37-62))
Mechanical properties of INOR-8 cast metal, 17: 32573 (ORNL-TM-607)
Moderator materials, 17: 33324 (ORNL-3445(p.218-50))
MSRE design data sheets, 17: 33375 (ORNL-TM-638)
Neutron cross section program, 2/15–8/1/63, 17: 33005 (ORNL-TM-636)
Nuclide chain equations for digital machine calculations, 17: 33244 (ORNL-TM-361(Add.))
Oak Ridge isochronous cyclotron guide for users, 17: 33118 (ORNL-TM-643)
ORNL GCR-3—750 Mw(e) gas-cooled clad-fuel reactor power plant, 17: 33305 (CONF-39-49)
Performance analyses of EGCR, 17: 33317 (ORNL-3445(p.3-29))
Plasma physics, 17: 33153 (ORNL-3472(p.24-49))
Plasma theory and computation, 17: 33157 (ORNL-3472(p.75-83))
Preparation of pure LiF, 17: 32193 (ORNL-TM-637)
Production, acceleration, and injection of ionic and atomic beams, 17: 33156 (ORNL-3472(p.70-4))
Prog. rpt. on gas-cooled reactors, 10/62–3/63, 17: 33316 (ORNL-3445)
Prog. rpt. on thermonuclear research, semiannual, 4/30/63, 17: 33150 (ORNL-3472)
Rod-drop method of rod calibration at ORR and LITR, 17: 33374 (ORNL-TM-605)
Shielding calculations—pot calcination demonstration, 17: 33397 (ORNL-TM-595)
Vacuum arc research, 17: 33154 (ORNL-3472(p.50-5))
Vacuum systems, techniques, and material studies, 17: 33159 (ORNL-3472(p.107-18))
Very high-energy injection into magnetic mirror, 17: 33160 (ORNL-3472 (p.119-20))
Vibrational spectra of molten salts, 17: 32041 (ORNL-3413)
**OHIO STATE UNIV., COLUMBUS.**
$\nu_3$ and $\nu_4$ bands of the $NT_3$ molecule, 17: 32048 (TID-19213)
Six-meter focal length Ebert-type infrared spectrograph. I and II., 17: 32341 (TID-19175)
**OKLAHOMA STATE UNIV., STILLWATER.**
Computation curves for axi-symmetric base pressure analysis, 17: 32730 (TID-19116)

# P

**PARIS. UNIVERSITÉ.**
Free carriers produced by electron bombardment in CdS, 17: 32668 (NP-13019)
Recoil protons from e-p scattering at 950 Mev, 17: 32905 (LAL-1072)
**PENNSYLVANIA STATE UNIV., UNIVERSITY PARK.**
Neutral scalar theory with recoil, 17: 32899 (CONF-46-80)
Vaporization of Pr–Group V compounds, 17: 32033 (CONF-20-5)
**PHILLIPS PETROLEUM CO. ATOMIC ENERGY DIV., IDAHO FALLS, IDAHO.**
Differential calorimeter for radiation-induced power, 17: 32333 (CONF-39-53)
Energy differential neutron cross sections as applied to reactor physics, 17: 32994 (CONF-39-37)
Operation of nuclear test reactors. I., 17: 33371 (IDO-16871-1)
**PISA, ITALY. UNIVERSITÀ.**
Measurement of cardiopulmonary blood volumes by means of radiocardiography, 17: 31818 (TID-19168)
Prog. rpt. on radiocardiographic techniques, annual, 7/20/63, 17: 31819 (TID-19173)
Transistorized digital ratemeter, 17: 32340 (TID-19170)
**PITTSBURGH. UNIV.**
Stability of molten U and refractory carbides, 17: 32036 (CONF-40-2)
**PRATT AND WHITNEY AIRCRAFT DIV., UNITED AIRCRAFT CORP., HARTFORD, CONN.**
Beryllium diffusion barrier coatings, 17: 32574 (PWA-2184)
**PRATT AND WHITNEY AIRCRAFT DIV., UNITED AIRCRAFT CORP. CONNECTICUT AIRCRAFT NUCLEAR ENGINE LAB., MIDDLETOWN.**
Thermal decomposition of UN, 17: 32032 (CNLM-5066)

**PRINCETON UNIV., N. J.**
Decrease of plasma loss in stellarator, 17: 33145 (MATT-157)
Long-wavelength instability in reflex discharge, 17: 33147 (MATT-198)
Quasi-linear theory of plasma instabilities, 17: 33146 (MATT-169)

## R

**RADIO CORP. OF AMERICA. ELECTRON TUBE DIV., LANCASTER, PENNA.**
Electrode thermionic converter, 17: 32702 (ASD-TDR-63-442)
**REACTOR CENTRUM NEDERLAND, PETTEN.**
STRZ—program for steady-state temperature distribution, 17: 32248 (RCN-16)
**RENSSELAER POLYTECHNIC INST., TROY, N. Y.**
Asymptotic neutron spectra in multiplying media, 17: 32971 (CONF-11-6)
Diffusion parameters for $H_2O$ for various scattering kernels, 17: 32972 (CONF-11-7)
Electrochemical characteristics of rare earth and Y metals, 17: 32034 (CONF-20-22)
Water spectra and energy exchange kernels, 17: 32970 (CONF-11-5)
**ROCHESTER, N. Y. UNIV.**
Multiple Coulomb scattering in nuclear research emulsions, 17: 32907 (NYO-10271)
Prog. rpt. on somatic mutations in moth Ephestia, 8/63, 17: 31856 (TID-19166)
**ROCHESTER, N. Y. UNIV. ATOMIC ENERGY PROJECT.**
Device to measure Th-228 at natural levels, 17: 31984 (CONF-16-1)
Laboratory test chamber for studying air-borne materials, 17: 32292 (UR-629)
Participation of coagulation mechanism in tumor localization of $I^{131}$-labeled fibrinogen, 17: 31820 (UR-630)
**RURAL COOPERATIVE POWER ASSN., ELK RIVER, MINN.**
Elk River Reactor technical specifications, 17: 33315 (NP-12999)
Technical qualifications for nuclear plant operation, 17: 33328 (TID-19066)

## S

**SANDIA CORP., ALBUQUERQUE, N. MEX.**
Computation curves for axi-symmetric base pressure analysis, 17: 32730 (TID-19116)
Height-of-burst effects on long-range propagated pressures, 17: 32728 (SC-4687(RR))
Mathematical model for association memory, 17: 32475 (SCR-641)
Sedan long range blast propagation, 17: 31801 (PNE-202F)
Slide-dam construction employing nuclear explosives, 17: 32209 (SC-4781(RR))
Spectra and decay times of luminescences from chelated rare earth ions, 17: 31980 (CONF-37-4)
**SOUTH CAROLINA. UNIV., COLUMBIA.**
Prog. rpt. on waste disposal, 10/1/58–5/15/59, 17: 32044 (TID-19183)
Prog. rpt. on waste disposal, 6/1/60–9/1/60, 17: 32045 (TID-19184)
Prog. rpt. on waste disposal, 5/15–12/31/59, 17: 32046 (TID-19185)
**SPAIN. JUNTA DE ENERGIA NUCLEAR, MADRID.**
Nuclear processes produced by bombardment of acetylene with $He^3$ beam, 17: 32153 (JEN-119-DF/I-36)
**STANFORD UNIV., CALIF.**
EPR of uv-irradiated amino acids, polypeptides, and proteins, 17: 31850 (AD-294395)
**SYRACUSE UNIV., N. Y.**
Resonance production in $\Xi$ $K_F$ final state, 17: 32898 (BNL-7105)

## T

**TENNESSEE. UNIV., KNOXVILLE.**
Emission spectra of electron-irradiated metal foils, 17: 32669 (ORNL-3450)
High-density slag concrete, 17: 33222 (ORNL-3473)
**TENNESSEE. UNIV., OAK RIDGE. UT-AEC AGRICULTURAL RESEARCH LAB.**
Prog. rpt. on agricultural research, 7–12/62, 17: 31816 (ORO-605)
**TEXAS. AGRICULTURAL AND MECHANICAL COLL., COLLEGE STATION.**
Accumulation of organic materials by sedimentary particles in sea, 17: 31830 (TID-19127)
**TEXAS NUCLEAR CORP., AUSTIN, TEX.**
Nuclear techniques in coal analysis, 17: 31985 (CONF-124-1)

## U

**UNION CARBIDE NUCLEAR CO. Y-12 PLANT, OAK RIDGE, TENN.**
Extension of APT to obtain centroid and inertia information, 17: 32477 (Y-1420)
Nuclear Safety Handbook of Y-12 plant, 17: 32293 (Y-1272)
Stress corrosion cracking in U–Mo alloys, 17: 32518 (Y-1417)
**UNITED KINGDOM ATOMIC ENERGY AUTHORITY, LONDON.**
Prog. rpt. on UKAEA activities, annual, 4/62–3/63, 17: 31800 (NP-12981)
**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. REACTOR GROUP, DOUNREAY, CAITHNESS, SCOTLAND.**
Generation of acoustic noise by nucleate boiling, 17: 32251 (TRG-Report-549)
**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. RESEARCH GROUP. ATOMIC ENERGY RESEARCH ESTABLISHMENT, HARWELL, BERKS, ENGLAND.**
Emission of Xe-133 from irradiated $UO_2$, 17: 32563 (AERE-R-4347)
Faraday effect in semiconductors, 17: 32701 (AERE-R-4341)
Optimizing light collection in scintillation counters, 17: 32396 (AERE-R-3972)
**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. RESEARCH GROUP. WANTAGE RESEARCH LAB., WANTAGE, BERKS, ENGLAND.**
Determination of inorganic elements in biological tissue, 17: 31813 (AERE-R-4309)
**UNITED KINGDOM ATOMIC ENERGY AUTHORITY. WEAPONS GROUP. ATOMIC WEAPONS RESEARCH ESTABLISHMENT, ALDERMASTON, BERKS, ENGLAND.**
Determination of Pu-239, Pu-238 and Pu-236, 17: 32992 (AWRE-0-59/63)
**UNITED STATES–EURATOM JOINT RESEARCH AND DEVELOPMENT PROGRAM.**
Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)
Critical heat flux data for flow of steam–water mixtures, 17: 32245 (EURAEC-671)
Prog. rpt. on Garigliano reactor, 7/63, 17: 33311 (GEAP-4306)
Prog. rpt. on nuclear fuel, 6/63, 17: 32487 (NCSC-2981-4)
Prog. rpt. on Pu-recycle, 4–6/63, 17: 33240 (GEAP-4303)
Prog. rpt. on shaped burnable poison, 3–6/63, 17: 33236 (ACNP-63027)
Prog. rpt. on steam separation technology, 4–6/63, 17: 32206 (ACNP-63021)
Prog. rpt. on thermal-stress-fatigue of stainless steels, 4–6/63, 17: 32566 (ATL-A-137)
Prog. rpt. on transition boiling heat transfer, 4–6/63, 17: 32247 (GEAP-4307)
Prog. rpt. on two-phase flow, 4–6/63, 17: 32246 (GEAP-4251)
Prog. rpt. on U interstitial phases, 6/63, 17: 32486 (NCSC-2663-13)
Prog. rpt. on vapor volume fraction and slip velocity, 4/15–6/30/63, 17: 32241 (ACNP-63020)
Prog. rpt. on Zr alloy design, 4–6/63, 17: 32484 (GEAP-4284)
Radiation stability of UN, 17: 32660 (BMI-1638)

## V

**VIENNA. UNIVERSITÄT.**
Prog. rpt. on ion exchange separation of U and Th, 4/63, 17: 32194 (TID-19068)
**VIRGINIA POLYTECHNIC INST., BLACKSBURG.**
Polarization of neutrons from D(d,n)$He^3$ reaction, 17: 32996 (CONF-46-78)

## W

**WAKE FOREST COLL., WINSTON-SALEM, N. C.**
*In vivo* activation in mice of C-12, N-14, and O-16, 17: 31851 (BNL-6989)

**WESTERN RESERVE UNIV., CLEVELAND.**
Kinetics of γ radiolysis of chloroform, 17: 32155 (TID-19203)
**WESTINGHOUSE ELECTRIC CORP. ATOMIC POWER DIV., PITTSBURGH.**
Digital computer program for thermodynamic properties of $D_2O$, 17: 32038 (CVNA-129)
Fortran program for unit cell nuclear design calculations, 17: 33238 (CVNA-146(Vols.I&II))
Prog. rpt. on miniature neutron detector, 1–3/63, 17: 32404 (WCAP-2274)
**WESTINGHOUSE ELECTRIC CORP. BETTIS ATOMIC POWER LAB., PITTSBURGH.**
Explicit forms and recursion relations for T matrices, 17: 32919 (WAPD-T-1579)
Reduction of thermal activation rates to continuous spectrum, 17: 33245 (WAPD-T-1582)
**WISCONSIN. UNIV., MADISON.**
Atomic effects on nuclear reaction yield curves, 17: 32998 (CONF-52-3)
Prog. rpt. on thermoluminescent radiation dosimetry, 17: 32402 (TID-19112)

## Y

**YALE UNIV., NEW HAVEN.**
Prog. rpt. on radiation effects on forest trees, 6/61–5/62, 17: 31854 (TID-19067)

# PERSONAL AUTHOR INDEX

Each entry after an author's name is a shortened version of the title of the report or article, followed by the *NSA* volume and abstract number. Report numbers are given in parentheses.

The phrase "Progress report" is abbreviated as "Prog. rpt.," permitting a more rapid and complete alphabetical arrangement of the titles without changing the location of the progress report titles in relation to the other titles.

Because of problems involving the mechanical preparation of this index, all accent marks are omitted. The following changes in spelling have been introduced to reduce some of the confusion which might result from omitting the accents:

| | | |
|---|---|---|
| ä | becomes | ae |
| ö | | oe |
| ø | | oe |
| ü | | ue (except in transliterated Chinese names) |

## A


**ABAGYAN, L. P.**, Effect of cross-section blocking with allowance for Doppler broadening, 17: 33021

**ABBOTT, Helen M.**, Bibliography on composite materials. Suppl. I., 17: 32482 (AD-408618)

**ABDULAEV, G. B.**, Thermal conductivity of A(III) and B(V) compounds, 17: 32629

**ABELEVA, E. A.**, Dependence of occurrence of lethal mutation in Drosophila spermatogenesis on neutron dose, 17: 31936

**ABIDI, S. T. H.**, X-ray non-diagram lines, 17: 32777

**ABLITT, J. F.**, Reactor safety, 17: 33259

**ABRAHAM, Bernard M.**, Tritium production by neutron irradiation of Al–Li, 17: 33110

**ABRAHAM, F.**, Interactions of heavy nuclei with energy >$10^{12}$ev/nucleon, 17: 32893

**ABRAHAMSON, S.**, Induced mutation rates in sperm of *Drosophila melanogaster*, 17: 31895

**ABUZEID, M. A.**, Reaction $Al^{27}(p,\alpha_0)Mg^{24}$ at 1 to 2.5 Mev, 17: 33045

**ACCARY, A.**, Shaping semi-metallic nuclear fuels, 17: 33278

**ADACHI, Akira**, Effect of Zr on grain size in Fe and steel, 17: 32627

**ADAIR, Harry W.**, Calorimetric measurements of absorbed dose, 17: 32305

**ADAMS, J. M.**, Critical heat flux in nucleate boiling, 17: 32259

**ADAMS, R. A.**, Coordinated design of radioisotope laboratories, 17: 31805

**ADDA, Yves**, Kirkendall effect and chemical and intrinsic diffusion coefficients in U–Mo, 17: 32578 (AEC-tr-5932)

**ADDA, Yves**, Uranium–Zr diffusion in γ phase, 17: 32577 (AEC-tr-5931)

**ADEMBRI, G.**, Vibrational assignment of isoxazole-$d_3$, 17: 32145

**AFONIN, A. A.**, Model of $\pi$-$\pi$ interaction, 17: 32950

**AGEEVA, E. D.**, Properties of polycomponent Li silicate glasses, 17: 32098

**AGRAWAL, O. P.**, Polarography of Ce in $Li_2SO_4$, 17: 32099

**AINSCOUGH, J. B.**, Irradiation of sintered $UO_2$ to high burn-up, 17: 32686

**AINSWORTH, Alan**, Improvements in manipulating devices, 17: 32237

**AKASOFU, S.-I.**, Deformation of magnetic shells during magnetic storms, 17: 32864

**AKASOFU, Syun-Ichi**, Main phase of magnetic storms and the ring current, 17: 32878

**AKHUNDOV, T. S.**, Determination of specific volume of $D_2O$, 17: 32060

**AKISHIN, P. A.**, Vapor pressure of $ZrF_4$, 17: 32116

**ALBERIGI QUARANTA, A.**, Fast transistorized pulse amplifier, 17: 32359

**ALBRIGHT, Lyle F.**, Vapor phase nitration of propane: effect of γ radiation and temperature, 17: 32175

**ALDER, Kurt**, Theory of multiple Coulomb excitation with heavy ions, 17: 33087

**ALDERMAN, Ilo M.**, Sensitivity of irradiated mice to bacterial endotoxin, 17: 31921

**ALEKSANDROVA, M. F.**, Reaction of blood system of dogs in chronic Sr-90 irradiation, 17: 31930

**ALEKSEEVA, K. I.**, Ionization-momentum relation for particles in relativistic region, 17: 32453

**ALESSANDRINI, A.**, Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)

**ALEXANDER, J. M.**, Neutron-deficient isotopes of La, 17: 33023

**ALI-EL-FARASH**, Preparation of thin β-ray sources and U convertors, 17: 32770

**ALIEV, G. M.**, Thermal conductivity of A(III) and B(V) compounds, 17: 32629

**ALKIRE, G. J.**, Inorganic ion exchange separation of Cs, 17: 33396 (HW-SA-2920)

**ALLEN, K. R.**, Cloud chamber study of electron avalanche growth, 17: 32786

**ALLEN, R. A.**, Kramers' and line radiation from $N_2$ and air shocks, 17: 32705 (BSD-TDR-63-102)

**ALLENDEN, D.**, Control system for neutron spectrometer, 17: 32433

**ALY, F. M.**, Reaction $Al^{27}(p,\alpha_2)Mg^{24}$ at 1 to 2.5 Mev, 17: 33045

**AMATO, I.**, Rate of grain growth of $UO_2$, 17: 32600

**AMBROZHII, M. N.**, Thermal decomposition of $Sn_2O_3$ and Ce(IV), 17: 32109

**AMELINCKX, S.**, Radiation damage in alpha U, 17: 32681

**AMIRKHANOV, Kh. I.**, Radiogenic Ar in minerals and rocks, 17: 32278

**ANACREON, R.**, Infrared spectra of some $B^{11}$-labeled diboranes, 17: 32079

**ANANEV, Yu. A.**, Four-level optical generator, 17: 32804

**ANDERSEN, A. C.**, Experimental dog survival, 17: 31868 (UCD-107(p.275-81))

**ANDERSEN, A. C.**, Pathology report on beagles, 17: 31867 (UCD-107 (p.129-274))

**ANDERSEN, A. C.**, Prog. rpt. on irradiated beagles, annual, 6/63, 17: 31857 (UCD-107)

**ANDERSEN, A. C.**, Radiation effects on beagle reproduction. I., 17: 31865 (UCD-107(p.98-111))

**ANDERSEN, A. C.**, Radiation effects on beagle reproduction. II., 17: 31866 (UCD-107(p.112-28))

**ANDERSEN, James C.**, Fuel composition for nuclear reactors, 17: 33298

**ANDERSON, Carl E.**, Excitation functions for Li-6 induced reactions on Au-197, 17: 33038

**ANDERSON, G. W.**, Radiation kills bacteria in frozen eggs, 17: 31889

**ANDERSON, Herbert R., Jr.**, High-energy radiation effects in polymeric materials, 17: 32700

**ANDERSON, J. D.**, Scattering of 14-Mev neutrons from N and O, 17: 33006 (UCRL-7192)

**ANDERSON, Lowell L.**, Cross section of Cu-63 for nuclear accident dosimetry, 17: 33000 (CONF-67-15)

**ANDERSON, R. K.,** Utility system conditions favorable to installation of nuclear power, 17: 33348
**ANDERSSON, C. I. Gunnar,** Calculations of optimum material distributions, 17: 33237 (AE-110)
**ANDREEFF, Alexander,** Lithium-glass scintillators for detection of neutrons, 17: 32405 (ZFK-RN-19)
**ANG, Wang-shou,** Operation of neutron diffractometers, 17: 32368
**ANGRIST, S. W.,** Performance of a Nernst effect generator, 17: 32832
**ANGRIST, S. W.,** Thermoelectric and thermomagnetic generators, 17: 32831
**ANTOLKOVIC, B.,** Yields of D-D neutrons from different targets, 17: 32768
**ANTONOVA, L. I.,** Lanthanum tellurides, 17: 32121
**ANTOUFIEV, Y. P.,** Reaction $Al^{27}(p,\alpha_0)Mg^{24}$ at 1 to 2.5 Mev, 17: 33045
**AOKI, Shigeo,** Oxidation of Zr–Al and Zr–Mo base ternary alloys, 17: 32621
**APIRION, D.,** Genetics of ascospore color in *Aspergillus nidulans*, 17: 31893
**APOSTOL, A.,** Preparation of nuclear emulsion with fine granulation, 17: 32407
**ARABADZHAN, A. S.,** Reciprocal system formed by chlorides and bromides of Li and Tl, 17: 32113
**ARAKAWA, E. T.,** Emission spectra of electron-irradiated metal foils, 17: 32669 (ORNL-3450)
**ARCHULETA, R. F.,** Genetic effects of x irradiation of male mice, 17: 31853 (LADC-5618)
**ARD, W. B.,** Plasma physics, 17: 33153 (ORNL-3472(p.24-49))
**ARENDARCIK, J.,** Hemagglutination and coagulation after irradiation of dogs, 17: 31953
**ARIFULINA, R. A.,** Mechanism of action of chemical protective substances. I., 17: 31940
**ARKHIPOV, R. G.,** Galvanomagnetic effects and electron spectrum of graphite, 17: 32641
**ARMSTRONG, A. A., Jr.,** Prog. rpt. on waste disposal, 10/1/58–5/15/59, 17: 32044 (TID-19183)
**ARMSTRONG, J. C.,** Charged-particle detector for magnetic analyzers, 17: 32428
**ARMSTRONG, W. A.,** Radiolysis of cystine solutions. I., 17: 32158
**ARMSTRONG, W. D.,** Bone Ca and Sr discrimination, 17: 31841
**ARMSTRONG, William A.,** Fluorometric determination of cerous ion, 17: 31996
**ARNOLD, E. D.,** Shielding calculations—pot calcination demonstration, 17: 33397 (ORNL-TM-595)
**ARON, P. R.,** Physical properties of deposited $Nb_3Sn$, 17: 32647
**ARONOWITZ, Leonard,** Diagnostic studies of pinch plasma accelerator, 17: 33196
**ARSENAULT, Claudette,** Effects of heavy ions and electrons on hair depigmentation, 17: 31882
**ARTHUR, Paul D.,** Electrothermal arc-jet propulsion systems, 17: 32219
**ARUTYUNYAN, F. R.,** Compton effect on relativistic electrons, 17: 32960
**ASHBAUGH, P. G.,** Negative ion production from beams of 35–200 kev positive ions, 17: 32838
**ASLANOV, S. M.,** Ternary system containing chlorides of Li, Na, and Ba, 17: 32120
**ASTAKHOV, K. V.,** Spectrophotometric studies of Sm(III) and Eu(III) complex formation, 17: 32110
**ASTNER, G.,** Hindered E2 ground state transition in Po-207, 17: 33039
**ATALLA, Laura T.,** Determination of gamma isomer in hexachlorocyclohexane by isotope dilution, 17: 32029
**AUCHAMPAUGH, G. F.,** Fission cross section of U-235, 17: 33058
**AUER, P. L.,** High-frequency electrostatic instabilities in plasma, 17: 33195
**AUERBACH, E. H.,** Optical-model neutron transmission coefficients, 17: 32968 (BNL-765)
**AVEYARD, Sydney,** Ultrasonic methods of testing, 17: 32263
**AYANT, Yves,** Line intensities in two-quantum transitions, 17: 32765
**AZAM, Noel,** Improvements in or relating to ion guns, 17: 32841

## B

**BACH, D. R.,** Asymptotic neutron spectra in multiplying media, 17: 32971 (CONF-11-6)
**BAECKSTROEM, G.,** Compton-scattered $\gamma$ rays for nuclear excitation, 17: 33034
**BAETSLE, L.,** Treatment of wastes by mineral ion-exchanger separation, 17: 33408
**BAILEY, M. L.,** Nuclear Safety Handbook of Y-12 plant, 17: 32293 (Y-1272)
**BAIR, W. J.,** Absorption of $Sr^{90}SO_4$ from the lung, 17: 31835
**BAKER, B. L.,** Prog. rpt. on waste disposal, 10/1/58–5/15/59, 17: 32044 (TID-19183)
**BAKER, B. L.,** Prog. rpt. on waste disposal, 6/1/60–9/1/60, 17: 32045 (TID-19184)
**BAKER, B. L.,** Prog. rpt. on waste disposal, 5/15–12/31/59, 17: 32046 (TID-19185)
**BAKER, J. L. L.,** Bubble motion in turbulent liquid stream, 17: 32250 (TID-19224)
**BAKER, W. F.,** Properties of quadrupole magnet doublets, 17: 32703 (BNL-795)
**BALABAN, Alexandru T.,** Tritiation of aromatics, 17: 32142
**BALACHANDRAN, A. P.,** Uniqueness of partial wave amplitudes, 17: 32904 (EFINS-63-40)
**BALARIN, Manfred,** Building of color centers in ion crystals by x irradiation, 17: 32671 (ZFK-WF-22)
**BALCIUS, J. F.,** Separation of Sc-49 from Ca target, 17: 32164
**BALDWIN, R.,** Engineering, 17: 31799 (BNL-782(p.92-4))
**BALESCU, R.,** Kinetic equation for an unstable plasma, 17: 33167
**BALL, R. M.,** Prototype nuclear-fueled thermionic converter test, 17: 32836
**BALLANTINE, D.,** Radiation, 17: 31796 (BNL-782(p.44-50))
**BALLINI, R.,** Two-dimensional registration in coincidence, 17: 32423
**BALUKOVA, V. C.,** Sorption and migration of radioactive elements in soils, 17: 33409
**BAM-ZELIKOVICH, G. M.,** Conducting gas flow in strong electromagnetic fields, 17: 32755
**BANICK, C. J.,** Determination of Am-243 in Cm-244, 17: 31997
**BANKS, Othniel Niel,** Nuclear reactor core structures, 17: 32236
**BARANIK, A. T.,** Reaction $Al^{27}(p,\alpha_0)Mg^{24}$ at 1 to 2.5 Mev, 17: 33045
**BARANOV, V. B.,** Calculations of a boundary on dielectric plane, 17: 32781
**BARASHENKOV, V. S.,** Cross sections for strange particle production. II., 17: 32920
**BARBER, M.,** Mass spectrometer for studying chemical reactions, 17: 32360
**BARBER, M.,** Mass spectrometric sampling, 17: 32361
**BARBIELLINI, G.,** Cross section for production of pairs from photons in crystals, 17: 32711 (LNF-62/113)
**BARCATTA, F.,** Materials for ion propulsion, 17: 32498
**BARGER, V.,** Neutral scalar theory with recoil, 17: 32899 (CONF-46-80)
**BARKAN, S.,** Diffusion cloud chamber for fast neutrons, 17: 32422
**BARNETT, C. F.,** Cross sections, 17: 33155 (ORNL-3472(p.56-69))
**BAROCH, C. J.,** Coextruded stainless steel-clad $UO_2$ fuel rods, 17: 32536 (GEAP-4282)
**BARRETT, N. T.,** Prestressed concrete pressure vessels, 17: 33254
**BARSCHALL, H. H.,** Scattering of polarized neutrons by $\alpha$ particles, 17: 32932
**BARTA, J.,** Systems of UC, $UC_2$, and UN with transition metals, 17: 32637
**BARTH, F.,** Diffusion of fission products through graphite, 17: 33273
**BARTH, F.,** Release of fission products from UC–ZrC fuel inserts, 17: 33272
**BARTHOLOMEW, G. A.,** Neutron physics, 17: 32725 (PR-P-57(p.37-43))
**BARTHOLOMEW, G. A.,** Spin 5/2 and 1/2 levels in Cr-51, Cr-53, Fe-57, and Ni-59, 17: 33090
**BARTLETT, A. A.,** Decay of V-48, 17: 33056
**BARTLETT, E. S.,** Protection of refractory metals, 17: 32526
**BARTLETT, Edwin S.,** Properties of F-48 Nb alloy, 17: 32567 (BMI-X-249)
**BARTNITSKII, E. N.,** Radiogenic Ar in minerals and rocks, 17: 32278
**BARTON, George W., Jr.,** Enhancement of signal-to-noise ratio by continuous averaging, 17: 32363
**BARTRAM, S. F.,** Rare earth borates, 17: 32035 (CONF-20-28)
**BASHSHALIEV, A. A.,** Thermal conductivity of A(III) and B(V) compounds, 17: 32629
**BATCH, J. M.,** Surge suppressors for PRTR process tube meters, 17: 33368 (HW-70711(Rev.))
**BATCHELOR, R.,** Reaction $H^3(t,n)He^4$ as neutron source, 17: 33035

**BATTLE, Norman,** Joints between tubular members, 17: 32228
**BAUER, Ernest,** Electron-ion-atom three-body recombination, 17: 32816
**BAUER, R. W.,** Scattering of 14-Mev neutrons from N and O, 17: 33006 (UCRL-7192)
**BEALE, Robert J.,** Electric space cruiser, 17: 32221
**BEAR, Wyman K.,** Coordinated design of radioisotope laboratories, 17: 31805
**BEATTIE, W. C.,** Operating experience with Indian Point station, 17: 33342
**BEAUCHAMP, H. A.,** Resonance model for $\gamma + N \rightarrow Y + K$, 17: 32966
**BEAUGE, R.,** Beryllium oxide bricks as neutron reflectors, 17: 33275
**BECKER, Josef,** Radiation research and radiation treatment, 17: 31826
**BECKER, Kurt M.,** Burnout conditions for flow of boiling water in vertical round ducts, 17: 32242 (AE-113)
**BECKER, Kurt M.,** Burnout conditions for flow of boiling water in vertical round ducts. II., 17: 32243 (AE-114)
**BECKER, M. C.,** Plasma physics, 17: 33153 (ORNL-3472(p.24-49))
**BECKURTS, K. H.,** Formation of neutron beams with special properties, 17: 32978
**BEEBY, J. L.,** Propagator for particle in presence of one-dimensional square-well potential, 17: 32938
**BEECHER, D. T.,** Design of superconducting magnet, 17: 32224
**BEERS, Lewis S.,** Upper-stage propulsion for Mars missions, 17: 33384
**BEGZHANOV, R. B.,** Resonance scattering of $\gamma$ quanta on Cu-65 and Ti-46, 17: 33076
**BEHOF, A. F.,** Polarization in neutron-deuteron elastic scattering, 17: 32935
**BELCHER, James H.,** Immunologically privileged sites in studies of polyoma tumor antigens, 17: 31915
**BELL, Geoffrey Hairsine,** Apparatus for determining vapor pressures, 17: 32391
**BELL, P. R.,** DCX-2, 17: 33152 (ORNL-3472(p.9-23))
**BELOUSOV, V. I.,** Vapor pressure of $ZrF_4$, 17: 32116
**BELTER, W. G.,** Disposal of wastes in U. S., 17: 33399
**BELYAKOV, M. A.,** Selective determination of elements on basis of $(\alpha,n\gamma)$ $(\alpha,p\gamma)$ reactions, 17: 32015
**BEMENT, A. L., Jr.,** Effects of cold work and neutron irradiation on Zy-2, 17: 32665 (HW-74955)
**BENDER, M.,** ORNL GCR-3—750 Mw(e) gas-cooled clad-fuel reactor power plant, 17: 33305 (CONF-39-49)
**BENEDICT, Manson,** Isotope separation principles, 17: 32472
**BENES, L.,** Structure and magnetic properties of Co layers, 17: 32579
**BENESOVSKY, F.,** Procedures for coating fuel particles, 17: 33279
**BENESOVSKY, F.,** Stability of $UC_2$ and C-stable regions in systems of UC with ZrC, HfC, NbC, and TaC, 17: 32617
**BENESOVSKY, F.,** Systems Th–Mo–C and U–Mo–C, 17: 32616
**BENISZ, J.,** Determination of Th concentration using nuclear emulsion plates, 17: 31988 (CEA-tr-A-1197)
**BENN, James,** Improvements in reactor fuel elements, 17: 33284
**BENSON, G. C.,** Surface energy of the {110} face of crystals, 17: 32749
**BENSON, Philip A.,** Extension of neutron activation analysis to $10^{-9}$ gram samples, 17: 32026
**BENT, R. D.,** Alpha particle breakup induced by inelastic scattering of $\alpha$ particles from C-12 and F-19, 17: 33097
**BENT, R. D.,** Lifetimes of levels in Ne-21, 17: 33098
**BENTLE, G. G.,** High-temperature mechanical properties of UC and BeO, 17: 32614
**BENVENISTE, J.,** Measuring energy of $\alpha$ beams from 5 to 30 Mev, 17: 32772
**BENZ, R.,** Preparation of ammonium U(IV) and ammonium Pu(IV) fluorides, 17: 32072
**BERENS, A. R.,** Infrared spectra for PVC and deuterated analogs, 17: 32606
**BERENYI, D.,** Detection of positrons in a magnetic $\beta$ spectrometer, 17: 32424
**BEREZIN, O. A.,** Flow of conducting fluid in transverse magnetic field, 17: 32813
**BERGDOLL, M. S.,** Sensitivity of thorotrast-treated monkeys to staphylococcal enterotoxin, 17: 31918
**BERGER, J. Alfred,** Stability of molten U and refractory carbides, 17: 32036 (CONF-40-2)
**BERGERON, C. J., Jr.,** Model for longitudinal force-free current flow in 17: 32741
**BERGHEIM, K.,** Slow neutron fission of U-235, 17: 33042
**BERGMAN, A. G.,** Reciprocal system formed by chlorides and bromides of Li and Tl, 17: 32113
**BERGMAN, A. G.,** Reciprocal system of Na and K pyrophosphates and fluorides, 17: 32114
**BERGSTROEM, I.,** Hindered E2 ground state transition in Po-207, 17: 33039
**BERINDE, A.,** Proton scattering by F-19 and Ar-40, 17: 33063
**BERS, A.,** Electron beam interactions with ions in warm plasma, 17: 33154
**BERTOLETTI, S.,** Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)
**BERTOLETTI, S.,** Critical heat flux data for flow of steam–water mixtures, 17: 32245 (EURAEC-671)
**BERUL, S. I.,** Reactions of $CeO_2$, $Nd_2O_3$, and $Sm_2O_3$ with molten fluorides, 17: 32111
**BETZLER, Karl-Erwin,** Construction of a hot laboratory, 17: 32211
**BEYSTER, J. R.,** Neutron thermalization in ZrH, 17: 32974 (GA-4328)
**BHAGAT, S. M.,** Growth of mutual friction in liquid He II, 17: 32752
**BHARADWAJ, P. D.,** Proton-nucleon interactions in nuclear emulsion at 28 Bev/c, 17: 32965
**BHATTACHARYYA, R.,** Gamma-gamma coincidences in Pd-105, 17: 33028
**BIALAS, Andrzej,** Continuity of Petrov classification, 17: 32737
**BICHSEL, R.,** Effect of Be contents on Al, 17: 32611
**BILINSKI, J. R.,** Proton-neutron damage correlation in semiconductors, 17: 32678
**BILLEN, Daniel,** Nature of a deoxynucleotide polymerase–DNA complex, 17: 31832
**BINDER, Daniel,** Radiation damage with neutron energy, 17: 32694
**BINGHAM, Robert,** Long-wavelength instability in reflex discharge, 17: 33147 (MATT-198)
**BINGO, Kazuyoshi,** Sensitivities of Fuji badge film to $\beta$ rays, 17: 32414
**BIRCHEN, D.,** Stress-corrosion cracking of austentic stainless steels, 17: 32529
**BIRKHOFF, G.,** Cathode ray tube for refining digital length measurements, 17: 32357
**BIRKHOFF, R. D.,** Emission spectra of electron-irradiated metal foils, 17: 32669 (ORNL-3450)
**BISHOP, G. R.,** Study of giant resonance in O-16, 17: 33052
**BITTEL, J. T.,** Thorium oxide—diffusion of oxygen in, compatibility with borides, and coating borides, 17: 32564 (ASD-TDR-63-635)
**BIZOT, J. C.,** Recoil protons from e-p scattering at 950 Mev, 17: 32905 (LAL-1072)
**BLACK, James F.,** Removal of S-35 and P-32 from organic moderator-coolants, 17: 33280
**BLANC, D.,** Adaptation of H-3 sources for measuring vacuum, 17: 32325
**BLANCO, R. E.,** Pot-calcination process, 17: 33403
**BLAUGRUND, A. E.,** First excited states of Re-185 and Re-187, 17: 33040
**BLEDSOE, L. J.,** DCX-2, 17: 33152 (ORNL-3472(p.9-23))
**BLEICHRODT, J. F.,** Artificial Be-7 in lower stratosphere, 17: 32759
**BLENNEMANN, D.,** Isotope exchange between H and liquid ammonia, 17: 32078
**BLESER, Edward J.,** Muonic molecules in liquid H, 17: 33003 (NEVIS-117)
**BLISS, Harding,** Diffusion in ion exchange resins, 17: 32053
**BLIZNYUKOV, S. A.,** Influence of rare earth metals on fused Fe, 17: 32598
**BLOCH, F.,** Stopping power of atoms having many electrons, 17: 33223 (UCRL-Trans-972)
**BLOCK, M. M.,** Structure of weak interaction $\Lambda + N \rightarrow N + N$, 17: 32903 (EFINS-63-39)
**BLOMEKE, J. O.,** Pot-calcination process, 17: 33403
**BLOOD, R. E.,** Prog. rpt. on Zr alloy design, 4–6/63, 17: 32484 (GEAP-4284)
**BLOOM, S. D.,** Electrons trapped in the earth's magnetic field following nuclear bursts, 17: 32845 (UCRL-7309(Rev.I))
**BLUMKIN, Samuel,** Thermal diffusion columns separating Xe isotopes, 17: 32469
**BOCCACCI, M.,** Factors affecting *in vitro* inactivation of aldolase by x-rays, 17: 31961
**BOCHKAREV, V. V.,** Measuring techniques for radioactive preparations, 17: 32456
**BODNER, S.,** Quasi-linear theory of plasma instabilities, 17: 33146 (MATT-169)
**BODOIA, J. R.,** Three-fluid nonequilibrium plasma accelerators. II.,

17: 33210
**BOGACHEV, N. P.**, Emission of Li-8 in disintegration of Ag and Br by protons, 17: 33081
**BOGAIEVSKI, M.**, Thermal conductivity of $UO_2$ up to 1200°C, 17: 32698
**BOGLYUBOV, V. A.**, Reduction of Nb concentrates by C, 17: 32492
**BOGOYAVLENSKAYA, M. P.**, Action of bone marrow transfusions in radiation sickness, 17: 31970
**BOKSHTEIN, S. Z.**, Self-diffusion of Mo in Mo–Zr alloys, 17: 32593
**BOLAND, Paul**, Prog. rpt. on materials for nuclear engineering applications, 7/62–6/63, 17: 32488 (TID-19057)
**BOLOGNA, G.**, Cross section for production of pairs from photons in crystals, 17: 32711 (LNF-62/113)
**BOLT, R. O.**, Effects of space radiation on organic materials, 17: 32693
**BOMAR, S. H.**, Prog. rpt. on materials for nuclear engineering applications, 7/62–6/63, 17: 32488 (TID-19057)
**BOND, C. D.**, Polarization of neutrons from D(d,n)$He^3$ reaction, 17: 32996 (CONF-46-78)
**BONDAR, L.**, Cathode ray tube for refining digital length measurements, 17: 32357
**BONDARENKO, T. G.**, Properties of $Li_2O$–$Cs_2O$–$La_2O_3$–$SiO_2$ glasses, 17: 32096
**BONDAREVA, T. P.**, Anodic oxidation of Zr in electrolytes, 17: 32528
**BONDESAN, C.**, Process for producing little $UO_2$ sintered spheres, 17: 32556
**BONIN, J. J.**, Evolution of stacking techniques, 17: 33250
**BONOMETTO, Silvio**, Measurement invariants for strong interactions, 17: 32924
**BONTE, F. J.**, Recording of scintillation scan data, 17: 32351
**BOONSTRA, B. H.**, STRZ—program for steady-state temperature distribution, 17: 32248 (RCN-16)
**BOOTH, G. C.**, Stress-corrosion cracking of austentic stainless steels, 17: 32529
**BOOTH, Rex**, Electric quadrupole moment of Te-125, 17: 33007 (UCRL-7297)
**BORISHANSKII, V. M.**, Heat transfer with longitudinal flow of Na in tube bundle, 17: 32253
**BOROVINA, V. I.**, Titration of Fe(2+) by Ce(IV) sulfate, 17: 32024
**BORTZ, P. I.**, Performance and analysis of a crossed-field accelerator, 17: 32835
**BORTZ, Paul I.**, Electron-ion reaction rate theory, 17: 33208
**BOSCH, H.**, Beta spectroscopy with solid-state detectors, 17: 32421
**BOSE, A.**, Dose-reduction factor for cysteamine, 17: 31909
**BOSE, S.**, Dose-reduction factor for cysteamine, 17: 31909
**BOSSELAAR, C. A.**, Infrared analysis of $H_2O$–$D_2O$ mixtures, 17: 32006
**BOSWARVA, I. M.**, Faraday effect in semiconductors, 17: 32701 (AERE-R-4341)
**BOUCHER, Roland**, Electric propulsion for control of stationary satellites, 17: 32220
**BOULENGER, Rene R.**, Detector for radon measurements, 17: 32459
**BOURELY, P.**, Fundamental research patents, 17: 32745
**BOURGUILLOT, R.**, Absolute age of uraniferous minerals of Katanga and Northern Rhodesia, 17: 32265
**BOURZES, M.**, Sintering, 17: 32497
**BOWEN, H. C.**, Wave functions for the H molecule and molecule ion, 17: 32767
**BOWEN, H. J. M.**, Determination of inorganic elements in biological tissue, 17: 31813 (AERE-R-4309)
**BOWEY, E. M.**, Nanosecond neutron time-of-flight system, 17: 33032
**BOWMAN, C. D.**, Fission cross section of U-235, 17: 33058
**BOWMAN, Charles D.**, Spark chamber as detector of fission fragments, 17: 32403 (UCRL-7169)
**BOWMAN, H. R.**, Kinetic energy and fine structure in spontaneous fission of Cf-252, 17: 32995 (CONF-46-44)
**BOYCE, Richard**, Ultraviolet-light inactivation of systems containing 5-bromouracil-substituted DNA. I., 17: 31885
**BOYCE, Richard**, Ultraviolet-light inactivation of systems containing 5-bromouracil-substituted DNA. II., 17: 31886
**BOYD, A. W.**, Radiolysis and pyrolysis of organic coolants, 17: 32165
**BRADBURY, B. T.**, Microstructural changes produced in $UO_2$ during irradiation, 17: 32690
**BRAGG, R. H.**, Effect of applied stress on graphitization of pyrolytic graphite, 17: 32649
**BRAININA, E. M.**, Zirconium cyclopentadienyl compounds, 17: 32144
**BRAND, P. B.**, Current applications of fiber optics to fluoroscopy, 17: 31822
**BRANDT, N. B.**, Effect of pressure on superconducting Cd, 17: 32803
**BRANDT, S. B.**, Radiogenic Ar in minerals and rocks, 17: 32278
**BRATSBERG, H. G.**, Zone refining of Al, 17: 32502
**BRAUER, F. P.**, Gamma spectrometry using $\beta$-$\gamma$ coincidence, 17: 32399 (HW-SA-2932)
**BRAUN, W. J.**, Does ring wear predict cylinder wear? Radiotracer data, 17: 32226
**BREE, J.**, Generation of acoustic noise by nucleate boiling, 17: 32251 (TRG-Report-549)
**BRENNAN, T. A.**, Current applications of fiber optics to fluoroscopy, 17: 31822
**BRENNER, Abner**, Electrodeposition of alloys. I., 17: 32510
**BRENNER, Abner**, Electrodeposition of alloys. II., 17: 32511
**BRESESTI, M.**, Irradiation facilities in Ispra I reactor, 17: 33365 (EUR-374.e)
**BRESLIN, A. J.**, Fallout protection in structures, 17: 31804 (WT-1462)
**BRETT, Charles Everett**, Prog. rpt. on marine invertebrate infauna distribution, 17: 31817 (TID-19122)
**BRETT, N. H.**, Sintering behavior and stability of $(PuU)O_2$ solid solutions, 17: 32634
**BREVNOVA, N. V.**, Deposition of Cs and Rb from $CO_2$ onto materials, 17: 32061
**BREZHNEVA, N. E.**, Solidification of radioactive waste solutions, 17: 33406
**BRICE, Neil**, Triggered very-low-frequency emissions, 17: 32868
**BRIDOUX, C.**, Resistance seam welding applied to stainless steel sheaths for fuel elements, 17: 32549
**BRIGGS, G.**, Systems of UC, $UC_2$, and UN with transition metals, 17: 32637
**BRIGGS, R. J.**, Electron beam interactions with ions in warm plasma, 17: 33194
**BRIM, W. W.**, $\nu_3$ and $\nu_1$ bands of the $NT_3$ molecule, 17: 32048 (TID-19213)
**BRITTON, C. F.**, Corrosion of Zr and its alloys, 17: 32520
**BRODSKY, Allen**, Increasing sensitivity of film measurements of $\gamma$ radiation intensities, 17: 32457
**BROECKER, Wallace S.**, Distribution of Cs-137 and Sr-90 in the oceans, 17: 32273
**BROGAN, T. R.**, Studies of fluid mechanics using MHD generator, 17: 33212
**BRONFIN, M. B.**, Self-diffusion of Mo in Mo–Zr alloys, 17: 32593
**BROOKS, A. L.**, Differential accumulation of I-131 from local fallout, 17: 31848
**BROOKS, E. H.**, Proton-neutron damage correlation in semiconductors, 17: 32678
**BROOKS, M. R.**, Genetic effects of x irradiation of male mice, 17: 31853 (LADC-5618)
**BROUDE, C.**, Spin assignment in even–even nuclei, 17: 33012
**BROUT, R.**, Phenomena along the hcp-bcc transition line of He-3 and He-4, 17: 32776
**BROWN, B.**, Experimental nucleonics, 17: 32455
**BROWN, D. J.**, Properties of UC, 17: 33265
**BROWN, F.**, Determination of Pu-239, Pu-238 and Pu-236, 17: 32992 (AWRE-O-59/63)
**BROWN, F.**, Range of Xe-133 and Ar-41 ions in W, 17: 32747
**BROWN, G. E.**, Single particle strengths in nuclei, 17: 33049
**BROWN, Paul Erskine**, Instrumentation and control for nuclear rockets, 17: 33389
**BROWN, W. B.**, Indirect determination of Th with EDTA, 17: 31993
**BROWNE, Louis**, Silicon rectifier developed as fast neutron sub-miniature dosimeter, 17: 32411
**BRUECHNER, H. J.**, Operating experience of Kahl Nuclear Power Station, 17: 33338
**BRUECKNER, J.**, Incorporation of [$H^3$] amino acids into the cell nucleus, 17: 31887
**BRUNE, D.**, Absolute disintegration rate of Cs-137 sources, 17: 32319 (AE-112)
**BRUTTO, E.**, Process for producing little $UO_2$ sintered spheres, 17: 32556
**BUCHSBAUM, S. J.**, Transmission of EM waves through plasma slabs, 17: 33218
**BUCK, T. M.**, Silicon p-n junction radiation detectors, 17: 32458

**BUDDE, R.,** Bubble chamber, 17: 32412
**BUDENHOLZER, R. A.,** Binary cycle for nuclear power generation, 17: 33351
**BUDESINSKY, B.,** Determination of C in U materials, 17: 32027
**BUDGE, W. L.,** Future of large reactors, 17: 33344
**BUDOV, G. M.,** Radiochemical studies of electrode processes on amalgams, 17: 32642
**BUDZINSKI, E. E.,** Satellite measurements in "Starfish" artificial radiation zone, 17: 32860
**BUECHE, A. M.,** Further NMR studies of polydimethylsiloxanes, 17: 32682
**BUECHLER, Alfred,** Geometry of $Li_2O$ by electric deflection, 17: 32030 (AROD-006.9)
**BUENEMANN, Dietrich,** Longitudinal and transversal plasma wave instabilities in two counterstreaming plasmas, 17: 33200
**BUGINAS, Scott J.,** Bibliography on weld properties, 17: 32533 (AD-409795)
**BUGL, Josef,** Radiation stability of UN, 17: 32660 (BMI-1638)
**BUGRYSHEV, P. F.,** Effect of stable Sr on metabolism and uptake of Sr-90, 17: 31831 (JPRS-19626)
**BULANOV, L. A.,** Thermal and radiation stability of aromatic compounds, 17: 32156
**BULEY, E. R.,** Electron-ion-atom three-body recombination, 17: 32816
**BUNTING, William L.,** Radiochromium-labeled lymphocytes in the rat, 17: 31917
**BUON, J.,** Recoil protons from e-p scattering at 950 Mev, 17: 32905 (LAL-1072)
**BUONI, Frederick B.,** Rod-drop method of rod calibration at ORR and LITR, 17: 33374 (ORNL-TM-605)
**BURBIDGE, G. R.,** Galactic halo—a transient phenomenon, 17: 32848
**BURGINYON, G. A.,** Nuclear and cosmic radiation in ocean, 17: 32718 (NP-12996(p.36-7))
**BURKHART, Lawrence E.,** Process simulation on digital computer, 17: 32474 (IS-698)
**BURLANKOV, D. E.,** Covariant conservation laws in general relativity, 17: 32805
**BURLANT, W.,** Radiation-initiated copolymerization of styrene, 17: 32177
**BURN, N.,** Negative ion production from beams of 35–200 kev positive ions, 17: 32838
**BURNETT, L.,** Dosage to important sites in radiation therapy, 17: 31872
**BUROV, I. V.,** Rare earth alloys, 17: 32648
**BURROWS, J. R.,** Satellite measurements in "Starfish" artificial radiation zone, 17: 32860
**BURSHTEYN, Ye. I.,** Reactivity of animals subjected to radiation, 17: 31974
**BURYKINA, L. N.,** Spermatogenesis in dogs in chronic Sr-90 injury, 17: 31929
**BUTEAU, L. J.,** Determination of alpha Zr $\{11\bar{2}1\}$ twinning elements, 17: 32632
**BUTLER, F. E.,** Corrosion to studies on stainless steel containing B-10, 17: 32517 (RFP-307)
**BUTLER, Frank,** Improvements in reactor fuel elements, 17: 33284
**BUTLER, J. W.,** Nuclear and cosmic radiation in ocean, 17: 32718 (NP-12996(p.38-42))
**BUTRA, F. P.,** Surface properties of alpha U. I., 17: 32602
**BUYST, L.,** Quantum statistical equilibrium for simple model. II., 17: 33231
**BYALOBZHESKII, A. V.,** Change in rate of electrodic reactions under irradiation, 17: 32171
**BYHAN, Hans Guenter,** Lithium-glass scintillators for detection of neutrons, 17: 32405 (ZFK-RN-19)
**BYRNE, J. T.,** Dicesium $PuCl_6$, proposed Pu standard, 17: 31991
**BYRON, S.,** Performance and analysis of a crossed-field accelerator, 17: 32835
**BYRON, Stanley,** Electron-ion reaction rate theory, 17: 33208

## C

**CAGLE, T. J.,** Nuclear Safety Handbook of Y-12 Plant, 17: 32293 (Y-1272)
**CAHEN, L.,** Absolute age of uraniferous minerals of Katanga and Northern Rhodesia, 17: 32265
**CAHEN, L.,** Ages of pegmatite and vein minerals from Rwanda and Burundi, 17: 32268
**CAHILL, Laurence J., Jr.,** Outer geomagnetic field, 17: 32862
**CAHILL, W. J.,** Operating experience at Indian Point Station, 17: 33357
**CAHN, J. H.,** Electron energy distribution functions in ionosphere, 17: 32882
**CAILLAT, R.,** Non-metallic fuel elements, 17: 33270
**CAILLAT, R.,** Thermal conductivity of $UO_2$ up to 1200°C, 17: 32698
**CALAME, Gerald P.,** Diffusion parameters of $H_2O$ for various scattering kernels, 17: 32972 (CONF-11-7)
**CALBOREANU, A.,** Corrections of finite geometry and energy in analysis of fast neutron polarization, 17: 32939
**CALIFANO, S.,** Vibrational assignment of isoxazole-$d_1$, 17: 32145
**CALIGIURI, G. P.,** Three-dimensional simulation of nuclear reactors, 17: 33268
**CALUSARU, A.,** Structure and magnetic properties of Co layers, 17: 32579
**CAMERON, J. R.,** Thermoluminescent dosimeter reading system, 17: 32448
**CAMERON, John R.,** Prog. rpt. on thermoluminescent radiation dosimetry, 17: 32402 (TID-19112)
**CAMERON, L. M.,** Triton-induced reactions on B-10, 17: 32997 (CONF-46-79)
**CAMPBELL, A. J.,** K x-ray yields from elements of low atomic number, 17: 32789
**CAMPBELL, B. L.,** Labeling sand with Au-198, 17: 31982
**CAMPOS, F. P.,** Neutron studies of nonstoichiometric metal hydrides, 17: 32580
**CANN, Gordon L.,** Hall current plasma accelerator, 17: 33205
**CAPE, J. A.,** Superconductivity and localized magnetic states in Ti–Mo alloys, 17: 32706 (CONF-23-19)
**CARLSON, R. H.,** Mass distribution and throwout studies, Project Sedan, 17: 31802 (PNE-217F)
**CARMICHAEL, H.,** General physics, 17: 32724 (PR-P-57(p.21-36))
**CAROTHERS, G. A.,** Determination of Am-243 in Cm-244, 17: 31997
**CARP, Richard I.,** Effects of $D_2O$ upon Simian $Virus_{40}$, 17: 31837
**CARPENDER, J. W. J.,** Radiation therapy with high-energy electrons, 17: 31870
**CARPENTER, D. L.,** Whistlers excited by nuclear explosions, 17: 32757
**CARROLL, J. G.,** Effects of space radiation on organic materials, 17: 32693
**CARRUTHERS, W. K.,** Trends in design and cost of fossil-fueled plant, 17: 32214
**CARSTENSEN, Peter B.,** Diagnostic studies of pinch plasma accelerator, 17: 33196
**CASAGRANDE, I.,** Present state of nuclear superheating, 17: 33336
**CASINI, G.,** Reactivity effects due to variations in nuclear parameters, 17: 33307 (EUR-281.e)
**CASPARI, Ernst W.,** Prog. rpt. on somatic mutations in moth Ephestia, 8/61, 17: 31856 (TID-19166)
**CASSIDY, M. E.,** Variable coincidence unit HASL-type TL-9, 17: 32409
**CASSIDY, Melvin E.,** Low-level $\beta$ scintillation counter, 17: 32410
Castillo, F. de la Cruz
*see de la Cruz Castillo, F.*
**CAULFIELD, H. J.,** Cesium compound semiconductors in thermionic energy converters, 17: 32830
**CAWSE, P. A.,** Determination of inorganic elements in biological tissue, 17: 31813 (AERE-R-4309)
**CAZEMAJOU,** Generation of pseudo-random gating impulse, 17: 32344 (AEC-tr-5901)
Cellini, R. Fernandez
*see Fernandez Cellini, R.*
**CERRAI, E.,** Beta radioactivity of plankton in Adriatic and Ligurian seas, 17: 31845
**CERRE, P.,** Treatment and packaging of solid waste irradiated in pile, 17: 33410
**CHABBAL, R.,** Measurement of temperature in PIG reflex pulse discharge, 17: 33168
**CHADBOURNE, L. E.,** Prog. rpt. on Hg-lubricated journal bearings, 10–12/62, 17: 32249 (SY-5455-R)
**CH'AI, K'ai-yueh,** Non-isochronic phenomenon in isochronous cyclotron, 17: 33136
**CHALUPA, B.,** Beam of polarized neutrons, 17: 32977
**CHAMPIGNY, M.,** Properties of $UO_2$-stainless steel fuel elements, 17: 33276
**CHAN, Hong-Mo,** Real unitary representation of the many-channel S matrix,

17: 32927
**CHANDRASEKHAR, S.**, Convective instability of gaseous masses, 17: 32743
**CHANG, Chung-ju**, Radiation effects on chromosomal rearrangements in spermatogenesis, 17: 31950
**CHANG, Ho-chi**, Photometry of large solar flares, 17: 32875
**CHANG, Huang-chio**, Operation of neutron diffractometers, 17: 32368
**CHANG, R.**, High-temperature mechanical properties of UC and BeO, 17: 32614
**CHAO, B. T.**, Bubble motion in turbulent liquid stream, 17: 32250 (TID-19224)
**CHAO, Kuang-Lai**, Relativistic theory of spin electron in Riemannian space, 17: 32963
**CHAPIRO, Adolphe**, Radiation chemistry of polymers, 17: 32176
**CHAPMAN, R. A.**, Cesium compound semiconductors in thermionic energy converters, 17: 32830
**CHARBONNIER, F. M.**, Voltage breakdown properties of Cs films, 17: 32827
**CHARLESWORTH, D. H.**, Stainless steel-sheathed $UO_2$ fuel elements, 17: 32662 (CRFD-1132)
**CHASE, Herman B.**, Effects of heavy ions and electrons on hair depigmentation, 17: 31882
**CHATEAU, D.**, Biological effect of localized irradiation, 17: 31883
**CHAUVIN, G.**, Electrorefining of nuclear metals, 17: 32499
**CHECHERNIKOV, V. I.**, Magnetic properties of Sc single crystals, 17: 32640
**CHEKALIN, N. V.**, Spin induction in electron paramagnetic resonance, 17: 32754
**CHEL'TSOVA, M. A.**, Thermal and radiation stability of aromatic compounds, 17: 32156
**CHEN, Chien-pou**, Image-forming characteristics of periodic field lenses, 17: 32369
**CHEN, Philip S., Jr.**, Comparison of natural inulin with its radioactive derivatives, 17: 31920
**CH'EN, Tieh-yu**, Properties of $Li_2O$–$Cs_2O$–$La_2O_3$–$SiO_2$ glasses, 17: 32096
**CHERNAVSKII, D. S.**, Describing interaction of high-energy particles, 17: 32952
**CHERNICK, C. L.**, Mössbauer effect in compounds of Xe-129, 17: 32089
**CHERNICK, J.**, Reactor physics, 17: 31794 (BNL-782(p.1-17))
**CHERNYAEV, I. I.**, Complex pentacid–uranyl oxalate–halide compounds, 17: 32119
**CHERTKOV, I. L.**, Transformation of hemopoietic cells in irradiated dogs, 17: 31969
**CHESHIRE, I. M.**, Electron capture by fast protons in H, 17: 33061
**CHESHKOV, A. A.**, Invariant parametrization of local operators, 17: 32953
**CHESWORTH, Arthur**, Improvements in reactor fuel elements, 17: 33284
**CHEVALLIER, A.**, Biological effect of localized irradiation, 17: 31883
**CHILTON, Arthur B.**, Gamma reflection factors from concrete, 17: 33224
**CHIPMAN, R. D.**, Stress analysis of HNPF loading-face shield, 17: 33251
**CHIRIKOV, B. V.**, Kinetics of induced Mössbauer radiation, 17: 33084
**CHITANI (TITAN), Yoichi (Yoiti)**, Glass for radiation sterilization of medicines, 17: 32675
**CHIU, H. Y.**, Supernovae, neutron stars, and two kinds of neutrino, 17: 32880
**CH'IU, Hsing-fang**, Radiation effects on chromosomal rearrangements in spermatogenesis, 17: 31950
**CHRISTENSEN, L. J.**, Scattering of 14-Mev neutrons from N and O, 17: 33006 (UCRL-7192)
**CHRISTIAN, R. S.**, Proton linear accelerators for energies up to 300 Mev, 17: 33113 (CONF-125-3)
**CHRISTIAN, R. S.**, Spiral-sector FFAG magnet design, 17: 33115 (CONF-125-5)
**CHRISTOFILOS, N. C.**, High-current linear induction accelerator for electrons, 17: 33119 (UCRL-7408)
**CHU, Tie-shen**, Operation of neutron diffractometers, 17: 32368
**CHUDNOW, Ivan**, Effects of $D_2O$ upon Simian Virus$_{40}$, 17: 31837
**CHUKHROV, M. V.**, Structure and properties of Mg–Th alloys, 17: 32596
**CHULKOV, P. M.**, Atmospheric contamination over Atlantic Ocean in 1961, 17: 31844
**CHUNG, Tao**, Vapor phase nitration of propane: effect of $\gamma$ radiation and temperature, 17: 32175
**CHURCH, Hugh W.**, Height-of-burst effects on long-range propagated pressures, 17: 32728 (SC-4687(RR))
**CHURCH, Hugh W.**, Sedan long range blast propagation, 17: 31801 (PNE-202F)
**CINA, B.**, Decomposition effects in $PuO_2$ on sintering, 17: 32080
**CINA, B.**, Segregation effects in sintered $UO_2$–$PuO_2$ pellets, 17: 32604
**CIORASCU, Florian**, Nuclear power research in Rumania, 17: 31811
**CLAES, W.**, Three-dimensional simulation of nuclear reactors, 17: 33268
**CLARK, D.**, Materials for ion propulsion, 17: 32498
**CLARK, W. E.**, Fixation of wastes in glassy solids, 17: 33405
**CLARK, W. E.**, Pot-calcination process, 17: 33403
**CLARKE, J. F. G., Jr.**, Multidentate ligand kinetics. III., 17: 32067
**CLAUSNITZER, G.**, Source of polarized protons, 17: 33130
**CLAUSS, A.**, Diffusion of fission products through graphite, 17: 33273
**CLAUSS, A.**, Release of fission products from UC–ZrC fuel inserts, 17: 33272
**CLAVE, Marcel**, Improvements in observation ports for enclosures, 17: 32235
**CLAVE, Serge**, Improvements in observation ports for enclosures, 17: 32235
**CLAXTON, T. A.**, Surface energy of the {110} face of crystals, 17: 32749
**CLAYTON, D. W.**, Radioactive tracers in pulp and paper research, 17: 32328
**CLAYTON, H. H.**, Theoretical physics, 17: 32727 (PR-P-57(p.69-85))
**CLEGG, A. B.**, Reaction $C^{13}(p,p)C^{13m}$, 17: 33043
**CLEGG, A. B.**, Reaction $C^{13}(p,\gamma)$ from 10 to 50 Mev, 17: 33044
**CLEMENT, M.**, Measurement of temperature in PIG reflex pulse discharge, 17: 33168
**CLIFFORD, A. F.**, Stoichiometry of praseodymium oxide, 17: 32071
**CLINE, H. E.**, Niobium–Th eutectic alloy as superconductor, 17: 32650
**COBB, W. C.**, Measurement of $\alpha$–$\gamma$ angular correlations, 17: 32446
**COCCA, U.**, Proton-neutron damage correlation in semiconductors, 17: 32678
**COCHE, A.**, Light impulse generators in the nanosecond region, 17: 32212
**COCHE, A.**, Slow component of luminous emission in organic scintillators, 17: 32426
**CODY, G. D.**, Physical properties of deposited $Nb_3Sn$, 17: 32647
**COEKELBERGS, R.**, Catalysis by irradiation in presence of non-metallic solids, 17: 32178
**COFFEY, D. L.**, Magnetics and superconductivity, 17: 33158 (ORNL-3472 (p.84-106))
**COHEN, Allan J.**, Direct nuclear electrogenerator cells, 17: 33391
**COHEN, Arnold D.**, Upper-stage propulsion for Mars missions, 17: 33384
**COHEN, Donald**, Oxides of Np(V) and Np(VI) from molten salts, 17: 32073
**COHEN, Jerry J.**, Methods of handling and laundering Be-contaminated garments, 17: 32291 (UCRL-7311)
**COJOCARU, V.**, Thermal neutron activation of natural isotopes, 17: 32709 (IFA/SN/17)
**COLBY, J. W.**, Kirkendall effect and chemical and intrinsic diffusion coefficients in U–Mo, 17: 32578 (AEC-tr-5932)
**COLBY, J. W.**, Uranium–Zr diffusion in $\gamma$ phase, 17: 32577 (AEC-tr-5931)
**COLE, F. T.**, Accelerator as pion factory, 17: 33114 (CONF-125-4)
**COLE, F. T.**, Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)
**COLGATE, Stirling A.**, Mass motion of high-altitude nuclear explosion, 17: 31803 (UCRL-7224(Rev.II))
**COLLIER, J. G.**, Steam/water mixtures flowing in heated annulus, 17: 32260
**COLLIN, Jacques**, Progress in mass spectrometry, 17: 32350
**COLOMBO, R. L.**, Rate of grain growth of $UO_2$, 17: 32600
**COLUSSI, S.**, Amplifier for neutron thermopile or thermocouple, 17: 32339 (RT/EL(63)3)
**COMAR, C. L.**, Effect of dietary K and Na on Cs-137 retention in rats, 17: 31826
**COMAR, C. L.**, Factors influencing biological availability of radionuclides, 17: 31839
**COMAR, C. L.**, Thyroidal deposition of radioiodine from milk, 17: 31849
**COMER, A. G.**, Radiation kills bacteria in frozen eggs, 17: 31889
**CONDOTTA, D. L.**, Fission product confinement for NPR, 17: 33363 (HW-SA-2891(Rev.))
**CONGDON, C. C.**, Increase in lysozyme activity in kidneys of irradiation chimeras, 17: 31919
**CONN, Marvin E.**, Removal of S-35 and P-32 from organic moderator-

coolants, 17: 33280
**CONNALLY, R. E.**, Gamma spectrometry using $\beta$-$\gamma$ coincidence, 17: 32399 (HW-SA-2932)
**CONNER, P.**, Chemical factors influencing the thermal oxidation of nuclear graphite, 17: 32128
**CONNOLLY, P. L.**, Resonance production in $\Xi K\pi$ final state, 17: 32898 (BNL-7105)
**CONRADS, H.**, Reproducibility of light emission from sliding spark gap in high vacuum, 17: 32710 (JUL-123-PP)
**CONSTANTINESCU, M.**, Organic solvents in cation exchange, 17: 32092
**CONSTANTINESCU, O.**, Organic solvents in cation exchange, 17: 32092
**COOKE, A. H.**, Magnetic relaxation in rare earth salts, 17: 32818
**COOLEY, James W.**, Calculations of electronic wave functions of diatomic molecules, 17: 32721 (NYO-10423)
**COOPER, E. C.**, Voltage breakdown properties of Cs films, 17: 32827
**COOPERMAN, Edward Lee**, Fission fragment kinetic energy as function of prompt $\gamma$ rays, 17: 33093
**COPPEZ, A.**, Bibliography of absolute dating measurements in Antarctic, 17: 32266
**COPPI, Bruno**, Hydromagnetic instabilities in multipolar systems, 17: 33175
**CORBETT, John D.**, Rare earth metal–metal halide systems. VI., 17: 32074
**CORDIN, Richard A.**, Reactor operator's approach to nuclear material management, 17: 33269
**CORIOU, H.**, Electrorefining of nuclear metals, 17: 32499
**CORNFIELD, Jerome**, Sensitivity of irradiated mice to bacterial endotoxin, 17: 31921
**CORNGOLD, Noel**, Velocity polynomials in neutron thermalization, 17: 32973 (CONF-39-46)
**COTTIER, H.**, Lymphocyte production measured by extracorporeal irradiation, 17: 31852 (BNL-7137)
**COTTON, F. A.**, Crystal and molecular structure of bis(dipivaloylmethanido)-zinc(II), 17: 32040 (NYO-10552)
**COUGHLIN, James**, Special Shift Control Reactor, 17: 33349
**COUSSON, L.**, French U technology, 17: 32183
**COUWENBERG, H. J. M.**, Zone-melting of oxides, 17: 32590
**COX, A. Lucile**, Controlled-growth colloidal ion source, 17: 32217
**COX, D. E.**, Magnetic structures in the MnSb–CrSb system, 17: 32622
**COXELL, H.**, Scintillator meson telescope, 17: 32419
**CRACKNELL, A. G.**, Stainless steel-sheathed $UO_2$ fuel elements, 17: 32662 (CRFD-1132)
**CRAIG, Wm. G.**, Solvolysis in light and heavy water. V., 17: 32063
**CRAMER, J. G., Jr.**, Alpha particle breakup induced by inelastic scattering of $\alpha$ particles from C-12 and F-19, 17: 33097
**CRAMER, J. G., Jr.**, Population of magnetic substates by inelastic $\alpha$-particle scattering, 17: 33099
**CRAMER, J. G., Jr.**, Scattering of $\alpha$ particles from O-16, Mg-24, and Si-28, 17: 33101
**CRIMMINS, D. H.**, ML-1 reactor stability tests, 17: 33302 (AGN-TM-403)
**CRITCHLOW, P. R.**, Growth of mutual friction in liquid He II, 17: 32752
**CROACH, J. W.**, Predicting physical properties in oriented metals, 17: 32631
**CROITORU, P.**, Charging of Van de Graaff generators, 17: 33134
**CROITORU, Z.**, Electrode phenomena, tensor conductivity and electrode heating in seeded Ar, 17: 33209
**CRONKITE, E. P.**, Lymphocyte production measured by extracorporeal irradiation, 17: 31852 (BNL-7137)
**CROOKS, D. D.**, Effect of applied stress on graphitization of pyrolytic graphite, 17: 32649
**CROSBY, G. A.**, Spectra and decay times of luminescences from chelated rare earth ions, 17: 31980 (CONF-37-4)
**CROWLEY, Cathryn**, Chromosome aberrations in liver cells, 17: 31958
**CROWLEY, Cathryn**, Life-span shortening from tissue insults, 17: 31827
**CROWNFIELD, Frederic R., Jr.**, Measurement of Faraday effect in magnetoplasma, 17: 33198
**CRUCQ, A.**, Catalysis by irradiation in presence of non-metallic solids, 17: 32178
**CULLEN, G. V.**, Grain boundaries in metals and ceramics, 17: 32584
**CULLER, Glen J.**, Plasma oscillations in external electric field, 17: 33172
**CURTIS, D. L.**, Single-phase induction plasma accelerator, 17: 33192
**CURTIS, H. J.**, Chromosome aberrations in liver cells, 16: 31958
**CURTIS, H. J.**, Life-span shortening from tissue insults, 17: 31827
**CURTIS, Howard J.**, Corn seeds affected by heavy cosmic particles, 17: 31947
**CUTHBERT, J.**, Mass spectrometer for studying chemical reactions, 17: 32360
**CZERNIEJEWSKI, F. R.**, Idealized Pu dissolvers, 17: 32895 (HW-SA-2999)
**CZIKEL, Josef**, Zirconium effect in Al alloys, 17: 32591

# D

**DAGNAC, R.**, Adaptation of H-3 sources for measuring vacuum, 17: 32325
**DAHANAYAKE, C.**, Flux of primary cosmic-ray $\alpha$ particles, 17: 32891
**DAHANAYAKE, C.**, Multiple Coulomb scattering in nuclear research emulsions, 17: 32907 (NYO-10271)
**DAINTREE, E. J.**, Magnetic relaxation in rare earth salts, 17: 32818
**DAITCH, P. B.**, Water spectra and energy exchange kernels, 17: 32970 (CONF-11-5)
**DALGARNO, A.**, Fluorescence of solar ionizing radiation, 17: 32873
**DALITZ, R. H.**, Outlook in hypernuclear physics, 17: 32901 (EFINS-63-32)
**DALITZ, R. H.**, Strong and weak interactions of bound $\Lambda$ particles, 17: 32900 (EFINS-63-29)
**DALITZ, R. H.**, Structure of weak interaction $\Lambda + N \rightarrow N + N$, 17: 32903 (EFINS-63-39)
**DAMOUTH, D. E.**, Elastic scattering of negative pions by protons, 17: 32906 (NP-12990)
**DAR, Y.**, First excited states of Re-185 and Re-187, 17: 33040
**DARDEN, S. E.**, Polarization in neutron-deuteron elastic scattering, 17: 32935
**DARDINI, C.**, Circuit to measure maximum energy of bremsstrahlung, 17: 32401 (LNF-63/17)
**DARLING, B. T.**, Quantum mechanical Hamiltonian in group operator form, 17: 33228
**DARRAS, R.**, Oxidation of UC in carbonic anhydride, 17: 32127
**DAS, P.**, Melting curve of He-4, 17: 32780
**DAS GUPTA, Sharda**, Use of Co-60 for production of materials, 17: 32329
**DATTA, R. K.**, Phase transitions in $LiAl_5O_8$, 17: 32599
**DAUM, C.**, Reaction $Na^{23}(d,p)Na^{24}$ nuclear structure of Na-24, 17: 33055
**DAVIDSON, J. M.**, Effect of massive neutron exposure on reactor graphite, 17: 32667 (HW-SA-2926)
**DAVIDSON, John K.**, Integrated nuclear power and fuel reprocessing stations, 17: 32203
**DAVIES, D.**, Emission of Xe-133 from irradiated $UO_2$, 17: 32563 (AERE-R-4347)
**DAVIES, J. A.**, Beta spectroscopy for study of anodic oxidation, 17: 32532
**DAVIES, J. A.**, Range of Xe-133 and Ar-41 ions in W, 17: 32747
**DAVIS, H. S.**, Fission product confinement for NPR, 17: 33363 (HW-SA-2891(Rev.))
**DAVIS, M. W., Jr.**, Calcination of waste in molten S, 17: 33402
**DAVIS, R. A.**, Stress-corrosion cracking of high-strength steels, 17: 32531
**DAVIS, R. C.**, Production, acceleration, and injection of ionic and atomic beams, 17: 33156 (ORNL-3472(p.70-4))
**DAVIS, T. N.**, Polar-cap visual aurora and magnetic activity, 17: 32865
**DAWSON, F. G.**, Burnup data from PRTR Pu–Al fuel element, 17: 32666 (HW-77935)
**DAWSON, I. M.**, Oxidation of graphite. I., 17: 32688
**DE, P.**, Dose-reduction factor for cysteamine, 17: 31909
**DEALY, John M.**, Activity coefficients in binary liquid metallic solutions, 17: 32633
**DEAN, P. N.**, Electronic processing and analysis of metabolic data, 17: 31815 (LADC-5627)
**DE BOER, W. G. R. M.**, X-ray reactions with regard to chemoprotection. VII., 17: 31900
**DE BRUYN OUBOTER, R.**, Melting curve of He-4, 17: 32780
**DECONNINCK, G.**, Angular distribution of deuterons in $Li^6(\alpha,d_0)Be^8$, 17: 33014
**DECOT, J.**, Catalysis by irradiation in presence of non-metallic solids, 17: 32178
**DE CRESCENTE, M. A.**, Thermal decomposition of UN, 17: 32032 (CNLM-5066)
**DE GAALON, Gilles**, Free carriers produced by electron bombardment in CdS, 17: 32668 (NP-13019)
**DEGOLS, L.**, Catalysis by irradiation in presence of non-metallic solids,

17: 32178
**DE GOTTAL, Ph.**, Correlations in a nonisothermal plasma, 17: 33182
**DE GRAZIO, R. P.**, Dicesium $PuCl_6$, proposed Pu standard, 17: 31991
**DEJONGHE, P.**, Treatment of wastes by mineral ion-exchanger separation, 17: 33408
**DE LA CRUZ CASTILLO, F.**, Spectrophotometric determination of rare earth elements. I., 17: 32002
**DELANGE, M.**, Industrial production of $UO_3$, 17: 33277
**DEL CASTILLO, G.**, Spiral-sector FFAG magnet design, 17: 33115 (CONF-125-5)
Delgado, F. Palomares
*see Palomares Delgado, F.*
**DELHAL, J.**, Absolute age of old formations of Kasai basement, 17: 32269
**DELMAS, R.**, Preparation of sinterable $UO_2$, 17: 33271
**DELMAS, R.**, Thermal conductivity of $UO_2$ up to 1200°C, 17: 32698
**DELONE, N. L.**, Radiation sensitivity of microspores of *Tradescantia paludosa* mitosis, 17: 31937
**DEL TURCO, A. M.**, Preparation of colloidal chromic phosphate, 17: 32075
**DELVES, L. M.**, Neutron-deuteron doublet scattering length. I., 17: 32937
**DELVES, L. M.**, Two-body methods for three-body problems, 17: 32922
**DELVES, L. M.**, Variation principles for an arbitrary operator. II., 17: 33230
**DELWICHE, R.**, Ages of pegmatite and vein minerals from Rwanda and Burundi, 17: 32268
**DE MANDIROLA, O. Brieux**, Spectrography of U and Ca silicates, 17: 32739
**DE MASTRY, J. A.**, Creep and tensile properties of Nb-base alloys, 17: 32568 (CONF-53-5)
**DEMETRIADES, S. T.**, Three-fluid nonequilibrium plasma accelerators. II., 17: 33210
**DE MIER, Warren V.**, Radioactive waste fractionization and packaging, 17: 33395 (HW-SA-2786)
**DEMILDT, Andre C.**, Analysis for O in the actinide metals, 17: 31992
**DENKOV, Yu. N.**, Symmetry group of quantum system anisotropic oscillator, 17: 32800
**DE MONTARDY, A.**, Electrode phenomena, tensor conductivity and electrode heating in seeded Ar, 17: 33209
**DEMORTIER, G.**, Angular distribution of deuterons in $Li^6(\alpha,d_0)Be^8$, 17: 33014
**DENISOV, S. P.**, Size of nuclei from $\pi^0$ photoproduction cross sections, 17: 33073
**DENT, Kenneth Henry**, Improvements in reactor fuel elements, 17: 33284
**DENT, Kenneth Henry**, Improvements in reactor fuel elements, 17: 33285
**DEREIGNE, Andre**, Thermal decomposition of $La_2(SO_4)_3 \cdot 9H_2O$. I., 17: 32062
**DERRICK, G. H.**, Two-body methods for three-body problems, 17: 32922
**DESBRUSLAIS, E. L.**, Performance of major plant items at Calder Hall, 17: 33339
**DESRUES, R.**, Oxidation of UC in carbonic anhydride, 17: 32127
**DEUCHARS, W.**, Reaction $H^3(t,n)He^4$ as neutron source, 17: 33035
**DEUTSCH, J. P.**, First excited states (2+) of Yb-170, Os-186, and Os-188, 17: 33015
**DE VOE, James R.**, Distillation techniques for radiochemical separations, 17: 32154 (NAS-NS-3108)
**DE WAPPNER, Blanca G.**, Determination of Ta and Nb minerals, 17: 31999
**DEWEY, William C.**, Distribution of P-32 in phantoms, 17: 31876
**DEY, Arun K.**, Lanthanum–thoron chelate, 17: 31983
**D'HOOP, H.**, Three-dimensional simulation of nuclear reactors, 17: 33268
**DIAZ, A.**, Experimental evaluation of fully loaded Elk River Reactor, 17: 33354
**DIBBS, H. P.**, Industrial applications of neutron activation, 17: 32330
**DICKERSON, R. F.**, Creep and tensile properties of Nb-base alloys, 17: 32568 (CONF-53-5)
**DIDCHENKO, R.**, Properties of rare earth monosulfides and nitrides, 17: 32081
**DIDDENS, A. N.**, $K^-$-p total cross section between 2.7 and 5.2 Bev/c, 17: 32897 (BNL-6962)
**DIEDRICH, James H.**, Materials problems associated with radiators for space powerplants, 17: 33393
**DI FERRANTE, Elvira R.**, Detector for radon measurements, 17: 32459
**DILLINGER, P.**, Absorption of $\beta$ radiation for determination of U and Th, 17: 32014
**DIX, T. J.**, Chemical factors influencing the thermal oxidation of nuclear graphite, 17: 32128
**DJUKIC, B.**, Therapeutic effect of P-32 on leucosis in poultry, 17: 31825
**DMITRIEV, V. N.**, Characteristics of ternary fission in U and Pu, 17: 33019
**DOBBS, H. E.**, Use of xerography for autoradiography, 17: 32352
**DOERING, John P.**, Excitation of $N_2^+$ first negative system in bombardment of $N_2$ by $N_2^+$, 17: 32707 (CONF-46-43)
**DONALDSON, W. T.**, Determination of Am-243 in Cm-244, 17: 31997
**DONATO, L.**, Measurement of cardiopulmonary blood volumes by means of radiocardiography, 17: 31818 (TID-19168)
**DONATO, Luigi**, Prog. rpt. on radiocardiographic techniques, annual, 7/20/63, 17: 31819 (TID-19173)
**DONNELLY, R. G.**, Brazing graphite to itself, 17: 32547
**DORN, D. W.**, Production of transuranium elements in a thermonuclear explosion—Anacostia, 17: 32733 (UCRL-7314(Rev.I))
**DOSORTSEVA, R. L.**, Chromosome aberrations as function of irradiation intensity, 17: 31902
**DOSSIN, J. B.**, Angular distribution of deuterons in $Li^6(\alpha,d_0)Be^8$, 17: 33014
**DOUGLAS, Thomas B.**, Thermodynamic properties of MgO and BeO, 17: 32086
**DOUGLASS, D. L.**, Prog. rpt. on Zr alloy design, 4–6/63, 17: 32484 (GEAP-4284)
**DOUGLASS, R. M.**, Preparation of ammonium U(IV) and ammonium Pu(IV) fluorides, 17: 32072
**DOWDY, Andrew H.**, Problems peculiar to electron therapy, 17: 31824
**DRAGANU, M.**, Equation of MHD oscillations of sphere, 17: 33184
**DRAPCHINSKII, L. V.**, Characteristics of ternary fission in U and Pu, 17: 33019
**DREWES, G. W. J.**, Dynamic polarization of protons in polystyrene, 17: 32779
**DREYER, G. A.**, Stress-corrosion cracking of high-strength steels, 17: 32531
**DRITS, M. E.**, Neodymium solution in Mg, 17: 32594
**DRITS, M. E.**, Properties of Mg–Th–Mn system, 17: 32595
**DROEGKAMP, R. Eugene**, Nuclear fuel element and fabrication, 17: 33294
**DRUDING, Leonard F.**, Rare earth metal–metal halide systems. VI., 17: 32074
**DRUMMOND, William E.**, Theory of plasma wave probes in collisionless plasma, 17: 33183
**DUBERG, John E.**, Laboratory for space radiation effects, 17: 32699
**DUCK, Ian**, Vector form factor in pion $\beta$ decay, 17: 32934
**DUCLOS, Donald P.**, Diagnostic studies of pinch plasma accelerator, 17: 33196
**DUKHOVICH, F. S.**, Behavior of radioisotopes incorporated in glass blocks, 17: 33404
**DUMAZERT, M.**, Diffusion cloud chamber for fast neutrons, 17: 32422
**DUNAITSEV, A. F.**, Measurement of Panofsky ratio by coincidences, 17: 32947
**DUNGEY, J. W.**, Loss of Van Allen electrons due to whistlers, 17: 32889
**DUNLAP, J. L.**, DCX-1 plasma experiments, 17: 33151 (ORNL-3472(p.1-8))
**DVORNIKOVA, L. M.**, Thermal decomposition of $Sm_2O_3$ and Ce(IV), 17: 32109
**DWYER, O. E.**, Chemistry and chemical engineering, 17: 31795 (BNL-782 (p.18-43))
**DYCK, M.**, Aging of high polymers, 17: 32677
**DZEGANOVSKII, V. P.**, Fine structure of Sc's x-ray absorption K-spectra, 17: 32589

## E

**EAGER, R. L.**, ESR spectra of γ-irradiated thiosulfate, 17: 32746
**EASTWOOD, T. A.**, Cobalt resonance capture integral, 17: 33025
**EBERHARDT, P.**, Absolute age of uraniferous minerals of Katanga and Northern Rhodesia, 17: 32265
**ECCLESTON, Barton H.**, Purification of radioactive organic compounds, 17: 32140
**ECKERT, E. R. G.**, Heat transfer bibliography, 17: 32257
**ECKERT, E. R. G.**, Laminar free convection in $CO_2$, 17: 32258
**EDGE, R. D.**, Reactions produced by B-10, 17: 33105
**EDGE, R. D.**, Reactions induced by α-particle bombardment of B-11, 17: 33107

**EDWARDS, H. S.,** Thorium oxide—diffusion of oxygen in, compatibility with borides, and coating borides, 17: 32564 (ASD-TDR-63-635)
**EDWARDS, R. S.,** DCX-1 plasma experiments, 17: 33151 (ORNL-3472(p.1-8))
**EDWARDS, T. W.,** Proton linear accelerators for energies up to 300 Mev, 17: 33113 (CONF-125-3)
**EFIMENKO, J.,** Vaporization of Pr–Group V compounds, 17: 32033 (CONF-20-5)
**EFIMOV, A. N.,** Composition of vapor phase over nitric acid solutions, 17: 33400
**EFIMOV, G. V.,** Local quantum field theory without ultraviolet divergences, 17: 32807
**EGELSTAFF, P. A.,** Formation of neutron beams with special properties, 17: 32978
**EGOROVA, V. F.,** Four-level optical generator, 17: 32804
**EHLER, A. W.,** Prog. rpt. on $H_2$ dissociation, 5/15–8/14/63, 17: 32732 (TID-19169)
**EICHLER, Eugene,** Nuclear chemistry. II., 17: 32815
**EIDSON, W. W.,** Population of magnetic substates by inelastic $\alpha$-particle scattering, 17: 33099
**EIDSON, W. W.,** Scattering of $\alpha$ particles from O-16, Mg-24, and Si-28, 17: 33101
**EIDUS, L. Kh.,** Mechanism of action of chemical protective substances. I., 17: 31940
**EILENBERG, Stanton L.,** Mission capabilities of electric propulsion, 17: 32223
**EKSTROM, F. E.,** High-temperature mechanical properties of UC and BeO, 17: 32614
El-Farash, Ali
*see Ali-El-Farash*
**ELISEEV, A. A.,** Lanthanum tellurides, 17: 32121
**ELKINA, N. I.,** Effect of Pu-239 on phosphatase activity and on Ca, P, and N contents of bone tissue, 17: 31926
**ELLISON, M. A.,** Solar flares and associated phenomena, 17: 32871
**ELMING, Joergen,** Ship reactors at present and in the future, 17: 33335
**EL-RAMLY, Nabil,** Binary cycle for nuclear power generation, 17: 33351
**ELSEA, A. R.,** Large-size furnaces for heat treating metal assemblies, 17: 32207 (DMIC-Memo-167)
**ELSTON, J.,** Beryllium oxide bricks as neutron reflectors, 17: 33275
**ELYARD, C. A.,** Effect of $UO_2$ of controlling grain growth during sintering, 17: 32635
**EMERSON, L. C.,** Emission spectra of electron-irradiated metal foils, 17: 32669 (ORNL-3450)
**ENGLEMANN, Rudolph H.,** Electronic integrating circuit, 17: 32395
**ENJYO, Toshio,** Heat treatment of Zr-rich alloys, 17: 32626
**EPINAT'EVA, A. M.,** Data on pulse shape induced in drill holes, 17: 32271
**ERB, Tom L.,** Parameters for background radiation measurements, 17: 32312
**ERBEN, E.,** Effects of C and N on properties of Nb, 17: 32612
**EREMIN, A. A.,** Solidification of radioactive waste solutions, 17: 33406
**ERIKSSON, L.,** Hindered E2 ground state transition in Po-207, 17: 33039
**ERIKSSON, Olle,** Burnout conditions for flow of boiling water in vertical round ducts. II., 17: 32243 (AE-114)
**ERMANOVA, T. A.,** Sorption and migration of radioactive elements in soils, 17: 33409
**EROFEEVA, I. N.,** Nuclear particle spectrum at 3260 m altitude, 17: 32892
**ERVIN, Guy, Jr.,** Extraction of Ti, Zr, and Hf, 17: 32514
**ESTRADA, L.,** Resonance and direct $\gamma$ ray interactions, 17: 33013
**EVANS, Howard T., Jr.,** Uranyl ion coordination, 17: 32093
**EVANS, J. A.,** Single particle strengths in nuclei, 17: 33049
**EVANS, J. E.,** Lifetimes of levels in Ne-21, 17: 33098
**EVANS, Robley D.,** Testing radium capsules for radon leakage, 17: 31879
**EVNINA, S. B.,** Properties of polycomponent Li silicate glasses, 17: 32098
**EVVARD, John C.,** How much future for electric propulsion, 17: 32210

## F

**FABIANI, D.,** 73.6-MHz radiofrequency installation for AdA, 17: 33116 (LNF-63/10)
**FADEEVA, V. I.,** Polymorphism of rare earth oxides, 17: 32058
**FAEGERQUIST, U.,** Hindered E2 ground state transition in Po-207, 17: 33039
**FAEHRMANN, K.,** Shielding measurements at the WWR-S reactor, 17: 33381
**FAETH, P. A.,** Stoichiometry of praseodymium oxide, 17: 32071
**FAGOT, J.,** Fission cross section of U-233, 17: 33029
**FAIFER, S. I.,** Magnesium cermets and Mg–Be alloys, 17: 32553
**FAIRCHILD, W. W.,** Scintillator meson telescope, 17: 32419
**FAIRMAN, L.,** Deposition of Zr coatings, 17: 32507
**FALEYEVA, Z. N.,** Influence of radiation-induced chromosomal aberrations on viability of cells, 17: 31897
**FANG, Shou-hsien,** Non-isochronic phenomenon in isochronous cyclotron, 17: 33136
Farash, Ali El
*see Ali-El-Farash*
**FARGO, Jarvis J.,** Fabrication of thin $UO_2$ plates, 17: 32534 (CONF-50-3)
**FARNHAM, D. M.,** Cost trends in hydroelectric developments, 17: 32216
**FARQUHARSON, J.,** Electro-pneumatic constant volume manometer, 17: 32337 (K-1577)
**FARRAR, P. A.,** Lattice parameters of Hf–O alloys, 17: 32630
**FARREN, J.,** Mass spectrometer for studying chemical reactions, 17: 32360
**FARREN, J.,** Mass spectrometric sampling, 17: 32361
**FARRIS, George J.,** Process simulation on digital computer, 17: 32474 (IS-698)
**FASCETTI, M.,** 73.6-MHz radiofrequency installation for AdA, 17: 33116 (LNF-63/10)
**FAST, R. W.,** Spiral-sector FFAG magnet design, 17: 33115 (CONF-125-5)
**FAUCITANO, A.,** Low $\gamma$ and neutron fluxes chemical dosimetry, 17: 32460
**FEDORCHENKO, A. M.,** Excitation of longitudinal waves in plasma by radio waves, 17: 33186
**FEDOTOVA, M. I.,** Bone marrow destruction in $\gamma$ irradiation, 17: 31931
**FEIST, H.,** Slowing down of fast electrons, 17: 32826
**FELD, Bernard T.,** Conference on photon interactions in Bev-energy range, Cambridge, Mass., 1/63, 17: 32908 (TID-7668)
**FELDERHOF, B. U.,** Transverse waves in Vlasov plasmas. III., 17: 33181
**FENN, R. W., Jr.,** Effect of applied stress on graphitization of pyrolytic graphite, 17: 32649
**FERGUSSON, J. E.,** Chemistry of Re and Tc, 17: 32137
**FERLENGHI, E.,** Production of electron pairs in thick converters, 17: 32713 (LNF-63/27)
**FERNANDEZ CELLINI, R.,** Determination of U extracted with methyl isobutyl ketone–TBP, 17: 32001
**FERNANDEZ CELLINI, R.,** Spectrophotometric determination of rare earth elements. I., 17: 32002
**FERNANDO, P. C. B.,** Flux of primary cosmic-ray $\alpha$ particles, 17: 32891
**FERRELL, Richard A.,** Critical current and electron depairing in superconducting films, 17: 32839
**FESHBACH, H.,** Resonance and direct $\gamma$ ray interactions, 17: 33013
**FESSENDEN, Frederic P.,** Diagnostic studies of pinch plasma accelerator, 17: 33196
**FIELD, F. H.,** Ion source pressures in mass spectrometers, 17: 32387
**FILIPPOV, A. I.,** Formation of mesic He in mixture of He and H, 17: 33080
**FILKOVA, E. M.,** Blood proteins and riboflavin metabolism during Ra therapy, 17: 31907
**FILOV, R. A.,** Ternary fission of U-235 with 14-Mev neutrons, 17: 33020
**FILOV, R. A.,** Triple fission of Pu, 17: 33079
**FINGER, Harold B.,** Managing the nuclear-rocket program, 17: 33385
**FINK, Richard D.,** Recoil range studies of nuclear reactions induced by heavy ions, 17: 33094
**FIORONI, F.,** Amplifier for neutron thermopile or thermocouple, 17: 32339 (RT/EL(63)3)
**FIRK, F. W. K.,** Nanosecond neutron time-of-flight system, 17: 33032
**FIRSOVA, E. V.,** Heat transfer with longitudinal flow of Na in tube bundle, 17: 32253
**FISCHER, G.,** Resistance seam welding applied to stainless steel sheaths for fuel elements, 17: 32549
**FISHER, J. R.,** Experimental evaluation of fully loaded Elk River Reactor, 17: 33354
**FISHER, P. S.,** Reaction $C^{13}(p,p)C^{13*}$, 17: 33043
**FISHER, P. S.,** Reaction $C^{13}(p,\gamma)$ from 10 to 50 Mev, 17: 33044
**FITE, L. E.,** Drift control in $\gamma$ spectrometer, 17: 32466
**FITE, Wade L.,** Charge exchange reactions, 17: 32837

**FLEISCHER, R. L.**, Charge particle tracks in glass, 17: 32696
**FLEITMAN, A.**, Metallurgy, 17: 31798 (BNL-782(p.60-91))
**FLEMING, J. D.**, Prog. rpt. on materials for nuclear engineering applications, 7/62–6/63, 17: 32488 (TID-19057)
**FLICKER, Herbert**, Response of semiconductor detectors to fission fragments, 17: 32792
**FLINN, P. A.**, Mössbauer effect for an impurity nucleus. I., 17: 33096
**FLOTOW, Howard E.**, Heat capacity of Dy metal, 17: 32654
**FLUEGGE, R. A.**, Plasma analysis with time-of-flight mass spectrometer, 17: 33213
**FLUHARTY, R. G.**, Energy differential neutron cross sections as applied to reactor physics, 17: 32994 (CONF-39-37)
**FOGEL, Yu. M.**, Two-electron charge of low-energy protons, 17: 33077
**FOKKER, A. D.**, Type IV solar radio emission, 17: 32877
**FOLLETT, E. A. C.**, Oxidation of graphite. I., 17: 32688
**FOLT, V. L.**, Infrared spectra for PVC and deuterated analogs, 17: 32606
**FOOS, Raymond A.**, Uranium oxide and thorium oxide recovery, 17: 32189
**FORSSBERG, A.**, Effect of x rays and botulinum toxin in survival of mice, 17: 31901
**FORTINI, Tomso**, Similar ionospheric responses of some recurring flares, 17: 32857
**FOSS, D.**, Zone refining of Al, 17: 32502
**FOSTER, E. L., Jr.**, Stability of molten U and refractory carbides, 17: 32036 (CONF-40-2)
**FOSTER, Kenneth**, Improvements in reactor fuel elements, 17: 33284
**FOWLER, A. H.**, Extension of APT to obtain centroid and inertia information, 17: 32477 (Y-1420)
**FOWLER, I. L.**, Very large $BF_3$ proportional counters, 17: 32447
**FOWLER, T. K.**, Plasma theory and computation, 17: 33157 (ORNL-3472 (p.75-83))
**FRAAS, A. P.**, Reactor moderator structure, 17: 33300
**FRAAS, A. P.**, Reflector for neutronic reactors, 17: 33299
**FRAEKI, R.**, Sensitivity of $BF_3$ proportional counter, 17: 32445
**FRALEY, Phillip E.**, Six-meter focal length Ebert-type infrared spectrograph. I and II, 17: 32341 (TID-19175)
**FRANCE, P. W.**, Electron paramagnetic resonance absorption studies of neutron-irradiated $\alpha,\alpha$-diphenyl-$\beta$-picryl hydrazine, 17: 32756
**FRANKE, V. A.**, Transition amplitudes of creation of more than two particles, 17: 32944
**FRANZ, I.**, Proton scattering by F-19 and Ar-40, 17: 33063
**FRANZINI, Paolo**, Transistorized digital ratemeter, 17: 32340 (TID-19170)
**FRASER, J. S.**, Kinetic energy and fine structure in spontaneous fission of Cf-252, 17: 32995 (CONF-46-44)
**FREEDMANN, Steven I.**, Performance and entropy production in MHD space power cycles, 17: 32824
**FREEMAN, J. J.**, Spectra and decay times of luminescences from chelated rare earth ions, 17: 31980 (CONF-37-4)
**FREIDLINA, R. Kh.**, Zirconium cyclopentadienyl compounds, 17: 32144
**FREMLIN, J. H.**, Radiative capture of heavy ions, 17: 33060
**FRENNET, A.**, Catalysis by irradiation in presence of non-metallic solids, 17: 32178
**FREUND, Peter G. O.**, Vector mesons as Regge poles in perturbation theory, 17: 32902 (EFINS-63-35)
**FREYBERG, R. H.**, Operating experience at Indian Point Station, 17: 33357
**FREYBURG, R. H.**, Operating experience at Indian Point Station, 17: 33342
**FRICKEN, R. L.**, Interactions of heavy nuclei with energy $>10^{12}$ev/nucleon, 17: 32893
**FRIED, Burton D.**, Plasma oscillations in external electric field, 17: 33172
**FRIEDMAN, E.**, Post-acceleration pulsing system, 17: 33126
**FRIEDMAN, Irving**, Deuterium content of raindrops, 17: 32272
**FRIEMAN, E.**, Quasi-linear theory of plasma instabilities, 17: 33146 (MATT-169)
**FRIEMAN, E. A.**, Two-particle correlation function for unstable plasma, 17: 33173
**FRIES, Paul**, Portable 18-Mev betatron, 17: 32610
**FROESE-GERTZEN, E.**, Analysis of radiation-induced genetic damage in seeds, 17: 31869
**FROLOV, V. V.**, Inhomogeneity of magnetic fields for NMR spectrometer, 17: 32367
**FROST, B. R. T.**, Irradiation behavior of monocarbide fuels, 17: 32691
**FUFAEVA, O. L.**, Surface properties of alpha U. I., 17: 32602
**FUHS, A. E.**, Magnetohydrodynamic flow angle indicator, 17: 32388
**FUJII, Isao**, Determination of O by 14-Mev neutron activation analysis, 17: 32022
**FUJITA, Akira**, Studies on fallout particles. III., 17: 32302
**FUKUI, S.**, Spark chamber with high detection efficiency, 17: 32417
**FULDE, Peter**, Critical current and electron depairing in superconducting films, 17: 32839
**FULFORD, P. J.**, Performance of mechanical seals for primary coolant pumps, 17: 32215
**FULLWOOD, R. R.**, Asymptotic neutron spectra in multiplying media, 17: 32971 (CONF-11-6)
**FULTZ, S. C.**, Fission cross section of U-235, 17: 33058
**FUNKE, Lothar**, Decay of Tm-168, 17: 33008 (ZFK-PHA-8)
**FURCHNER, J. E.**, Electronic processing and analysis of metabolic data, 17: 31815 (LADC-5627)

## G

**GAERTTNER, E. R.**, Asymptotic neutron spectra in multiplying media, 17: 32971 (CONF-11-6)
**GAGLIONE, P.**, Manganese-54 concentration from fallout in Italian mollusks, 17: 31847
**GAILITIS, M.**, Cross section behavior near threshold in Coulomb field, 17: 33083
**GAKKAISHI, Nippon Genshiryoku**, Mechanical strength of fuel cladding tube, 17: 32620
**GALAKTIONOV, Yu. P.**, Spectrophotometric studies of Sm(III) and Eu(III) complex formation, 17: 32110
**GALEEV, A. A.**, Stability of plasma in strong magnetic field, 17: 33188
**GALL, W. R.**, ORNL GCR-3—750 Mw(e) gas-cooled clad-fuel reactor power plant, 17: 33305 (CONF-39-49)
**GALLAGHAR, Robert G.**, Testing radium capsules for radon leakage, 17: 31879
**GALLAUGHER, W. C.**, Stress-corrosion cracking of high-strength steels, 17: 32531
**GALLIE, R. R.**, Measurements made during commissioning of WAGR, 17: 33346
**GALLIMORE, John C.**, Fission products released from irradiated U when heated in air. I., 17: 32287 (LF-9)
**GALONSKY, A.**, Accelerator as pion factory, 17: 33114 (CONF-125-4)
**GANASSI, E. E.**, Mechanism of action of chemical protective substances. I., 17: 31940
**GANS, P.**, Reactions of $UCl_4$ with tertiary phosphines, 17: 32064
**GAO, Chong-shou**, Spin and parity of the resonant state $Y_0$, 17: 32941
**GARD, G. A.**, Optimizing light collection in scintillation counters, 17: 32396 (AERE-R-3972)
**GARELIS, Edward**, Theory of pulsed neutron source measurements, 17: 32894 (CONF-39-47)
**GARRIOTT, O. K.**, Electron density profile in the F2 layer, 17: 32870
**GARROD, Claude**, Calculating ground-state properties of many-particle systems, 17: 33227 (NYO-10431)
**GARSOU, J. L.**, Ambient radioactivity and its actual increase, 17: 32276
**GASIOROWICZ, S.**, Graphical method in the analysis of $SU_3$, 17: 32896 (ANL-6729)
**GASKELL, C. S.**, Magnetization of Gd near Curie point, 17: 32646
**GASPARI, G. P.**, Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)
**GASPARI, G. P.**, Critical heat flux data for flow of steam–water mixtures, 17: 32245 (EURAEC-671)
**GATES, J. E.**, Design of shipping casks for irradiated fuel elements, 17: 32303
**GATES, John E.**, Radiation stability of UN, 17: 32660 (BMI-1638)
**GAUR, J. N.**, Ferrocyanide complexes of Zr, 17: 32101
**GAUSTER, W. F.**, Magnetics and superconductivity, 17: 33158 (ORNL-3472 (p.84-106))
**GEIGER, J. S.**, Absolute energy of Hg-198 412-kev $\gamma$ radiation, 17: 33050
**GELBARD, E. M.**, Explicit forms and recursion relations for T matrices, 17: 32919 (WAPD-T-1579)
**GELLER, R.**, Measurement of temperature in PIG reflex pulse discharge, 17: 33168
**GEORGE, A. M.**, Electrical properties of alpha $U_3O_8$, 17: 32562

(AEET/CD/13)
**GEORGI, J. R.,** Thyroidal deposition of radioiodine from milk, 17: 31849
**GERBAULET, K.,** Incorporation of [H³] amino acids into the cell nucleus, 17: 31887
**GERHART, J. M.,** Post-irradiation examination of $PuO_2$–$UO_2$ fuel, 17: 32663 (GEAP-3833)
**GERWIN, Richard A.,** Interaction of moving source currents with hydromagnetic fluid, 17: 32708 (D1-82-0254)
**GERWIN, Richard A.,** Long wavelength charge oscillations of cylindrical plasma, 17: 33144 (D1-82-0255)
**GIBB, O. L.,** Magnetohydrodynamic flow angle indicator, 17: 32388
**GIBBONS, J. H.,** Neutron capture and stellar nucleosynthesis, 17: 32883
**GIBBONS, R. A.,** Vacuum arc research, 17: 33154 (ORNL-3472(p.50-5))
**GIBBS, B. M.,** Effect on $UO_2$ of controlling grain growth during sintering, 17: 32635
**GILBODY, H. B.,** Ionization by protons in range 100 to 450 kev, 17: 32790
**GILL, J.,** EPR of uv-irradiated amino acids, polypeptides, and proteins, 17: 31850 (AD-294395)
**GILLES, A.,** Radioprotection and modifications induced by cysteamine, 17: 31888
**GINGELL, C. E. L.,** Transistorized nuclear instrumentation system for nuclear research, 17: 32347
**GINGERICH, K. A.,** Vaporization of Pr–Group V compounds, 17: 32033 (CONF-20-5)
**GINZBURG, N. I.,** Effect of pressure on superconducting Cd, 17: 32803
**GINZBURG, V. L.,** Pressure in theory of phase transitions of second kind, 17: 32806
**GIOIA, A.,** Process for producing little $UO_2$ sintered spheres, 17: 32556
**GIRARDEAU, M.,** Many-body problem for composite particles, 17: 32929
**GIRD, E.,** Organic solvents in cation exchange, 17: 32092
**GLAHE, H. C.,** Proton-nucleon interactions in nuclear emulsion at 28 Bev/c, 17: 32965
**GLEASON, G. Irving,** Preparing and producing I-131, 17: 32180
**GLEIT, Chester E.,** Extension of neutron activation analysis to $10^{-9}$ gram samples, 17: 32026
**GLIGORIJEVIC, J.,** Therapeutic effect of P-32 on leucosis in poultry, 17: 31825
**GOBBLE, L. P.,** Tensile properties of Be, 17: 32645
**GODBEE, H. W.,** Fixation of wastes in glassy solids, 17: 33405
**GODBEE, H. W.,** Pot-calcination process, 17: 33403
**GOEDDEL, W. V.,** Thermal stability studies of graphite–matrix fuel systems, 17: 32570 (GA-2880)
**GOETZ, C. A.,** SNAP-8 reactor and shield, 17: 33392
**GOGGIN, P. R.,** Effects of electron irradiation on graphite, 17: 32685
**GOITTON, Jean,** Improvements in devices for identifying radioactive elements, 17: 32462
**GOLD, Sandra,** Radiation effects on small blood vessels, 17: 31874
**GOLDBERG, M.,** Resonance production in $\Xi$ K$\pi$ final state, 17: 32898 (BNL-7105)
**GOLDEN, Constance J.,** Low-thrust propulsion systems, 17: 32218
**GOLDMAN, A.,** Clad fuel development, 17: 33323 (ORNL-3445(p.199-217))
**GOLDMAN, A.,** Development of fueled-graphite bodies, 17: 33321 (ORNL-3445(p.111-37))
**GOLDMAN, A.,** Materials development for EGCR, 17: 33319 (ORNL-3445 (p.37-62))
**GOLDMAN, A.,** Moderator materials, 17: 33324 (ORNL-3445(p.218-50))
**GOLDMAN, L. M.,** Electron temperature in $\theta$ pinch determined from impurity line radiation, 17: 33214
**GOLDMANN, Jack B.,** Bibliography on microminiaturization, 17: 32338 (NP-12989)
**GOLDRING, G.,** First excited states of Re-185 and Re-187, 17: 33040
**GOLDRING, G.,** Measurements of gyromagnetic ratios, 17: 32771
**GOLDSTEIN, H.,** Formation of neutron beams with special properties, 17: 32978
**GOLDSTEIN, Howard S.,** Radiation vs. materials. II., 17: 32683
**GOLDSTEIN, L.,** Gyro-interaction of microwaves in magneto plasma in atmospheric gases, 17: 33215
**GOLDSTEIN, R. J.,** Heat transfer bibliography, 17: 32257
**GOLOVANOV, Yu. N.,** Solidification of radioactive waste solutions, 17: 33406
**GOODING, T. J.,** Physical processes in coaxial plasma gun, 17: 32225
**GOODLETT, C. B., Jr.,** Calcination of waste in molten S, 17: 33402
**GOODRICH, Max,** Computer activities of Spectroscopy Group at LSU, 17: 32481
**GOODWIN, Paul N.,** Calorimetric measurements of absorbed dose, 17: 32305
**GORBICS, S. G.,** Half-lives of Cs-137 and Co-60, 17: 32719 (NP-12996 (p.38-42))
**GORBUNOV, V. F.,** Atmospheric contamination over Atlantic Ocean in 1961, 17: 31844
**GORDEEVA, L. D.,** Formula for average number of fission neutrons, 17: 33016
**GORE, W. G.,** Precision auxiliary bias unit, 17: 32355
**GORMAN, J. G.,** Decrease of plasma loss in stellarator, 17: 33145 (MATT-157)
**GORNI, S.,** Post-acceleration pulsing system, 17: 33126
**GORSHKOV, G. V.,** Neutron yield from materials subjected to irradiation with $\alpha$ particles, 17: 33017
**GORSHKOV, G. V.,** Neutron yield from $(\alpha,n)$ reaction on Be, B, C, O, F, Na, Mg, Al, and Si, 17: 33018
**GORSHKOV, V. G.,** Atomic photoeffect at high energies, 17: 32810
**GORSUCH, T. T.,** Standardization of pure $\beta$-emitting nuclides, 17: 32413
**GORTSEMA, F. P.,** Properties of rare earth monosulfides and nitrides, 17: 32081
**GORYACHEVA, V. P.,** Reciprocal system of Na and K pyrophosphates and fluorides, 17: 32114
**GOUDSMIT, P. F. A.,** Influence of electron straggling on $\gamma$ energy determinations, 17: 32435
**GOURSKI, Eric,** Detector for radon measurements, 17: 32459
**GOVE, H. E.,** AECL tandem probes heavy nuclei interior, 17: 33125
**GOVE, H. E.,** Spin assignment in even–even nuclei, 17: 33012
**GOVIL, I. M.,** Half life of first excited state of I-129, 17: 33041
**GOVORKOV, B. B.,** Size of nuclei from $\pi^0$ photoproduction cross sections, 17: 33073
**GRAHAM, R. L.,** Absolute energy of Hg-198 412-kev $\gamma$ radiation, 17: 33080
**GRAHAM, R. L.,** Reactor neutron capture cross section of Ag-110m, 17: 33026
**GRANGER, Edward John,** Removing dust from a body, 17: 32318
**GRANOVSKII, Yu. I.,** Model of $\pi$-$\sigma$ interaction, 17: 32950
**GRANT, D. W.,** Radiolysis of cystine solutions. I., 17: 32158
**GRANT, Douglas W.,** Fluorometric determination of cerous ion, 17: 31996
**GRAVESON, R. T.,** Variable coincidence unit HASL-type TL-9, 17: 32409
**GRAVESON, Robert T.,** Low-level $\beta$ scintillation counter, 17: 32410
**GREEN, D. E.,** Neutron activation determination of Si, Zn, and Mg in GaAs, 17: 32004
**GREENE, John M.,** Hydromagnetic instabilities in multipolar systems, 17: 33175
**GREENE, Norbert T.,** Electrochemical characteristics of rare earth and Y metals, 17: 32034 (CONF-20-22)
**GREENSTEIN, J. L.,** Metal abundances in subgiant $\zeta$ Herculis, 17: 32852
**GREENSTREET, B. L.,** Experimental stress analysis of nuclear reactor pressure vessel, 17: 33252
**GREENSTREET, B. L.,** Moderator materials, 17: 33324 (ORNL-3445(p.218-50))
**GREGOR, L. V.,** Formation of thin polymer dielectric films by uv irradiation, 17: 32695
**GREINER, Walter,** Mixing of T = 0 and T = 1 states in giant resonance region of O-16, 17: 33004 (NP-12986)
**GRENACS, L.,** First excited states (2+) of Yb-170, Os-186, and Os-188, 17: 33015
**GRENAN, Marie M.,** Radioprotection by pressor amidines, 17: 31948
**GREULING, Eugene,** Induced effects in $\beta$ decay, 17: 33095
**GRIBAUMONT, A.,** Nuclear transfer reactions. IV., 17: 33022
**GRIBOV, V. N.,** Fermion Regge poles and meson-nucleon scattering, 17: 32933
**GRIEM, M. L.,** Radiation therapy with high-energy electrons, 17: 31870
**GRIFFIN, J. E.,** Transistorized time-amplitude converter, 17: 32358
**GRIFFITHS, L. B.,** Irradiation damage in UC, 17: 32689
**GRIGOREV, E. L.,** Emission of Li-8 in disintegration of Ag and Br by protons, 17: 33081
**GRIGOR'EV, Yu. G.,** Reception of ionizing radiation by organism, 17: 31908
**GRIGOROV, N. L.,** Nuclear particle spectrum at 3260 m altitude, 17: 32892
**GRINYUK, V. N.,** Uranium-based cermet alloys, 17: 32657

**GRITSYNA, V. T.,** Formation of isomer and ground states of nuclei in (p,n) reaction, 17: 33072
**GROH, Edward F.,** Fastener for an assembly of plates, 17: 33301
**GROSZEK, Aleksander Jerzy,** Apparatus for determining vapor pressures, 17: 32391
**GRUMMITT, W. E.,** Manual of low-activity environmental analyses, 17: 32282 (AECL-1745)
**GRUNE, Werner N.,** Parameters for background radiation measurements, 17: 32312
**GRUZDEV, G. P.,** Bone marrow destruction in γ irradiation, 17: 31931
**GUEBEN, M.,** Operational results of BR3, 17: 33341
**GUENAULT, A. M.,** Electron and phonon scattering, II., 17: 32785
**GUGAN, D.,** Electrical resistance of Li, 17: 32753
**GUHA, J.,** Systems of UC, $UC_2$, and UN with transition metals, 17: 32637
**GUIASU, Ileana,** Influence of residual interactions on nucleon–nucleus inelastic collision, 17: 33064
**GUIDI, Eugen,** Manipulators for replacing fuel in a reactor, 17: 32238
**GUIRAGOSSIAN, V.,** Linear amplifier for high counting rates, 17: 32334 (CONF-58-4)
**GULYAMOV, M.,** Ground state of Be-6, 17: 33078
**GUNDERSEN, Roy M.,** Shock waves in monatomic conducting fluids, 17: 32742
**GUNYE, M. R.,** Spin ⅜ and ½ levels in Cr-51, Cr-53, Fe-57, and Ni-59, 17: 33090
**GUREVICH, I. B.,** Action of bone marrow transfusions in radiation sickness, 17: 31970
**GURINSKY, D. H.,** Metallurgy, 17: 31798 (BNL-782(p.60-91))
**GUTHRIE, J. E.,** Manual of low-activity environmental analyses, 17: 32282 (AECL-1745)
**GUYADER, P.,** Properties of $UO_2$–stainless steel fuel elements, 17: 33276

# H

**HAALAND, Carsten M.,** Prog. rpt. on wave propagation under anomalous conditions, 12/15/62–3/15/63, 17: 32844 (ARF-A218-12)
**HABEL, Karl,** Immunologically privileged sites in studies of polyoma tumor antigens, 17: 31915
**HADDOCK, Roy P.,** Application of matrix method to Browne-Buechner spectrograph, 17: 32362
**HAERTIG, M.,** Strontium-90 contamination of men caused by food uptake, 17: 31846
**HAHN, J.,** Linear amplifier for high counting rates, 17: 32334 (CONF-58-4)
**HAIDUC, C.,** Preheating of feed water in combined nuclear power plants, 17: 33329
**HAKKA, Leo,** Solvolysis in light and heavy water. V., 17: 32063
**HALE, Francis J.,** Insulator boundary layers in MHD channels, 17: 33201
**HALL, A. M.,** Large-size furnaces for heat treating metal assemblies, 17: 32207 (DMIC-Memo-167)
**HALL, Charles A.,** Design of isotope storage area, 17: 32296
**HALL, R. M.,** Monitoring, decontamination, and bio-assay of Pu-contaminated injury, 17: 31962 (DPSPU-63-30-5)
**HALL, R. R.,** Production, acceleration, and injection of ionic and atomic beams, 17: 33156 (ORNL-3472(p.70-4))
**HALL, W. B.,** Electrode thermionic converter, 17: 32702 (ASD-TDR-63-442)
**HAMILTON, G. L.,** Three-fluid nonequilibrium plasma accelerators. II., 17: 33210
**HAMME, John V.,** Prog. rpt. on U interstitial phases, 6/63, 17: 32486 (NCSC-2663-13)
**HAMMOND, M. L.,** Effect of applied stress on graphitization of pyrolytic graphite, 17: 32649
**HAMPSON, B. L.,** Determination of Zr-95 and Nb-95 in seaweed and sea water, 17: 32005
**HANAK, J. J.,** Physical properties of deposited $Nb_3Sn$, 17: 32647
**HANCHER, C. W.,** Pot-calcination process, 17: 33403
**HANNA, G. C.,** Nuclear physics, 17: 32723 (PR-P-57(p.5-20))
**HANS, H. S.,** Half life of first excited state of I-129, 17: 33041
**HANSFORD, D. L.,** Separation of Li values, 17: 32205
**HAO, Chiao-shiu,** Photometry of large solar flares, 17: 32875
**HARDACRE, A. G.,** Optimizing light collection in scintillation counters, 17: 32396 (AERE-R-3972)
**HARDER, D.,** Slowing down of fast electrons, 17: 32826
**HARKNESS, R. L.,** Spectral observations of solar radio bursts. IV., 17: 32855
**HARKORT, D.,** Physical properties of sintered $UO_2$ bodies, 17: 32585
**HARLE, J. R.,** Production of radiation-induced genetic effects in plants, 17: 31951
**HARMER, D. S.,** Production of slow electrons and positive ions in He, Ne, Ar, $H_2$, $N_2$, $O_2$ and CO by helium ions, 17: 32731 (TID-19137)
**HAROLDSEN, Grant O.,** Vapor pressure water boiler reactor, 17: 33297
**HARRIS, D. R.,** Explicit forms and recursion relations for T matrices, 17: 32919 (WAPD-T-1579)
**HARRIS, G. I.,** Note on angular distribution analysis, 17: 33033
**HARRIS, J. H.,** Radiation through cylindrical plasma sheaths, 17: 33202
**HARRIS, L. P.,** Conductivity of Cs-seeded atmospheric pressure plasmas, 17: 33216
**HARRISON, A. G.,** Dissociation of formate esters by electron impact, 17: 32160
**HARRISON, J. E.,** Gamma-active fallout near Toronto, 1961–1962, 17: 32297
**HARRISON, Stanley,** Controlled-growth colloidal ion source, 17: 32217
**HARRISON, W. A.,** Electronic structure of series of metals, 17: 32659
**HART, E. L.,** Resonance production in Ξ Kπ final state, 17: 32898 (BNL-7105)
**HART, Hans,** New method of liquid density measurement using radiation, 17: 32321
**HART, R. G.,** Reactor neutron capture cross section of Ag-110m, 17: 33026
**HARTMAN, Charles W.,** Electrode sheath effects in pulsed, high-current discharges, 17: 32734 (UCRL-7357)
**HARTSOUGH, Walter D.,** Bevatron improvements, 17: 33120 (UCRL-10866)
**HARTWIG, H.,** Reproducibility of light emission from sliding spark gap in high vacuum, 17: 32710 (JUL-123-PP)
**HARVEY, M.,** Negative parity states in the nuclear (d,α) shell, 17: 33092
**HAUBACH, W. J.,** Gaseous thermal diffusion separation systems, 17: 32467 (CONF-8-5)
**HAUG, Hermann,** Systems $Eu_2O_3$–$UO_2$ and $PuO_2$–$Eu_2O_3$, 17: 32572 (NP-13003)
**HAUL, R.,** Isotope exchange between H and liquid ammonia, 17: 32078
**HAUSER, R.,** Fabrication of dense UC bars, 17: 32551
**HAUSER, R.,** Sintering of $UO_2$ in a continuous furnace, 17: 32550
**HAWKINS, R. C.,** Thermal conductivity of $UO_2$ under irradiation, 17: 32661 (CRDC-1143)
**HAWRYLAK, R. A.,** Continuous rotation scattering chamber, 17: 32393
**HAWTIN, P.,** Chemical factors influencing the thermal oxidation of nuclear graphite, 17: 32128
**HAYASHI, Mitsuoki,** Strontium-90 in bone of animals in Japan, 17: 32300
**HAYASHI, Shigenori,** Nuclear reactor spatial kinetics, 17: 33257
**HAYASHIBE, Yoshihiko,** Radiation copolymerization to cellulose. II., 17: 32676
**HAYWOOD, L. R.,** Candu to undersell coal, 17: 33331
**HAYWORTH, B. R.,** Physical processes in coaxial plasma gun, 17: 32225
**HAZEWINDUS, N.,** Gamma ray transitions in Cl-35, 17: 33059
**HEAGERTY, J. J.,** Utility system conditions favorable to installation of nuclear power, 17: 33348
**HEAL, K. G.,** Stainless steel-sheathed $UO_2$ fuel elements, 17: 32662 (CRFD-1132)
**HEIDELBERG, Joan G.,** Distribution of P-32 in phantoms, 17: 31876
**HEINER, R. E.,** Production of radiation-induced genetic effects in plants, 17: 31951
**HELFAND, E.,** Study of several lattice systems, 17: 32764
**HELFER, H. L.,** Metal abundances in subgiant ζ Herculis, 17: 32852
**HELLIWELL, R. A.,** Whistlers excited by nuclear explosions, 17: 32757
**HELLSTROEM, S.,** Absolute disintegration rate of Cs-137 sources, 17: 32319 (AE-112)
**HELM, J. W.,** Effect of massive neutron exposure on reactor graphite, 17: 32667 (HW-SA-2926)
**HEMPEL, K.,** Synthesis of $H^3$-labeled amino acids with high specific activity and their application, 17: 31842
**HEMPEL, Max,** Microstructure changes in irradiated alpha Fe, 17: 32673
**HEMSTREET, H. W.,** Cesium compound semiconductors in thermionic energy converters, 17: 32830
**HENDEL, H. W.,** Continuous plasma acceleration, 17: 33204
**HENDERSON, W. B.,** Burnup data from PRTR Pu–Al fuel element, 17: 32666 (HW-77935)

**HENDERSON, W. B.**, Program HACK—correction to sensor activity for decay and burnup, 17: 33241 (HW-78131)
**HENNEBERGER, Walter C.**, Hermiticity of Hamiltonians and existence of eigenstates in soluble field theories, 17: 32720 (NP-13004)
**HENRY, H. L.**, Physical Constants Testing Reactor Manual, 17: 33367 (HW-69714)
**HERB, B. G.**, The orbitron, 17: 32385
**HERB, R. G.**, Atomic effects on nuclear reaction yield curves, 17: 32998 (CONF-52-3)
**HERBJOERNSEN, O. H.**, Zone refining of Al, 17: 32502
**HERBST, W.**, Environmental radiation and its variability, 17: 31829
**HERENGUEL, Jean**, Zirconium and its alloys, 17: 32512
**HERFURTH, Klaus**, Zirconium effect in Al alloys, 17: 32591
**HERING, Burton**, Diffusion in ion exchange resins, 17: 32053
**HERZENBERG, A.**, Resonant electron scattering by atoms, 17: 32788
**HERZOG, Richard F. K.**, Ion source for solid materials, 17: 32389
**HESLOP, J. A. B.**, Neutron activation determination of Si, Zn, and Mg in GaAs, 17: 32004
**HESSON, G. M.**, Surge supressors for PRTR process tube meters, 17: 33368 (HW-70711(Rev.))
**HESTER, R. E.**, High-current linear induction accelerator for electrons, 17: 33119 (UCRL-7408)
**HEYNES, M. S. R.**, High melting-point glasses containing $UO_2$, 17: 32506
**HILARIS, Basil S.**, Afterloading in radiation therapy, 17: 31878
**HILBERT, Fritz**, Electron microscopy of irradiated sintered $UO_2$ pellets, 17: 32670 (ZFK-WF-21)
**HILL, Richard W.**, Spark chamber as detector of fission fragments, 17: 32403 (UCRL-7169)
**HILLMAN, M.**, Hot laboratory, 17: 31797 (BNL-782(p.51-9))
**HILLNHAGEN, Emil**, Microstructure changes in irradiated alpha Fe, 17: 32673
**HIMES, R. C.**, Crystalline phases of rare-earth tellurides, selenides, and sulfides, 17: 32125
**HIMMELSTEIN, P.**, Manufacture and use of UC for fuel elements, 17: 33248
**HIMOE, E.**, Induced mutation rates in sperm of *Drosophila melanogaster*, 17: 31895
**HINES, C. O.**, Magnetopause: New frontier in space, 17: 32876
**HINSCH, J.**, Radiation-initiated copolymerization of styrene, 17: 32177
**HIRSCH, P. B.**, Substructure and mechanical properties of refractory metals, 17: 32565 (ASD-TR-61-181(Pt.III))
**HITCHCOCK, H. C.**, Physical properties of deposited $Nb_3Sn$, 17: 32647
**HOCHSTETTER, Friedrich**, Metallurgy of U, 17: 32490
**HODGINS, J. W.**, Radiation-induced graft polymerization of styrene in wood, 17: 31807
**HOFF, F. W.**, STRZ—program for steady-state temperature distribution, 17: 32248 (RCN-16)
**HOFF, R. W.**, Production of transuranium elements in a thermonuclear explosion—Anacostia, 17: 32733 (UCRL-7314(Rev.I))
**HOFFMAN, H. W.**, Heat transfer and fluid flow, 17: 33326 (ORNL-3445 (p.298-328))
**HOFMANN, F.**, Manufacture of $UO_2$ fuel elements, 17: 33247
**HOH, F. C.**, Instability of Penning-type discharge, 17: 33176
**HOLDER, J.**, Preparation of sinterable $UO_2$, 17: 33271
**HOLL, Manfred M.**, Initial-fields specification problem, 17: 32846 (UCRL-13084)
**HOLLADAY, W. G.**, Resonance model for $\gamma + N \rightarrow Y + K$, 17: 32966
**HOLLAND, I. J.**, Beryllia ceramics, 17: 32491
**HOLM, G.**, Hindered E2 ground state transition in Po-207, 17: 33039
**HOLMES, J. F.**, Nuclear application of Pb, 17: 33256
**HOLMES, J. M.**, Pot-calcination process, 17: 33403
**HOLMES, J. M.**, Shielding calculations—pot calcination demonstration, 17: 33397 (ORNL-TM-595)
**HOLMGREN, H. D.**, Triton-induced reactions on B-10, 17: 32997 (CONF-46-79)
**HOLT, E. H.**, Radiometer for plasma afterglow study, 17: 33217
**HOLT, N. D.**, Prestressed concrete pressure vessels for reactors, 17: 33235 (AAEC/TM-198)
**HONCIA, G.**, Physical properties of sintered $UO_2$ bodies, 17: 32585
**HONIG, J. M.**, Stoichiometry of praseodymium oxide, 17: 32071
**HOOPER, J. W.**, Production of slow electrons and positive ions in He, Ne, Ar, $H_2$, $N_2$, O, and CO by helium ions, 17: 32731 (TID-19137)
**HOOVER, R. L.**, Energy levels in square well with hard core, 17: 33001 (CONF-128-1)
**HOOVERMAN, R. H.**, Orbits in logarithmic potential, 17: 32820
**HORD, Jesse**, Nucleation characteristics of cryogenic liquids, 17: 32829
**HORI, Shoichi**, Interactions in unitarity metric theory, 17: 33233
**HOROVITZ, Mark W.**, UNFOLD—program for analyzing linear systems, 17: 32476 (UCRL-10927)
**HORTON, K. E.**, Prog. rpt. on thermal-stress-fatigue of stainless steels, 4–6/63, 17: 32566 (ATL-A-137)
**HORVAT, Fr.**, Radioprotection and modifications induced by cysteamine, 17: 31888
**HORVAT, P.**, Low-lying states in Al-26, 17: 33057
**HOSHINO, Tsutomu**, Nuclear reactor spatial kinetics, 17: 33257
**HOUGHTON, G. K.**, Neutron thermalization in ZrH, 17: 32974 (GA-4328)
**HOVNANIAN, H. P.**, Current applications of fiber optics to fluoroscopy, 17: 31822
**HOWARTH, J. L.**, Surface ionization for high-energy EM radiation, 17: 31871
**HOWEY, G. R.**, Training program for nuclear power station personnel, 17: 33343
**HOYLE, F.**, Galactic halo—a transient phenomenon, 17: 32848
**HSIN, Shien-chieh**, Power supply for electrostatic analyzer, 17: 32370
**HSUEH, Ching-lan**, Radiation effects on chromosomal rearrangements in spermatogenesis, 17: 31950
**HU, Ning**, Derivation of one-particle Green's function, 17: 32948
**HU, Ren-Yu**, Measurement of dose rate of Ra $\gamma$ rays, 17: 32452
**HUANG, Nien-ning**, Ambiguity in phase-shift analysis of scattering processes, 17: 33234
**HUANG, R. Y.-M.**, Grafting polymers onto cellulose by high-energy radiation. II., 17: 31808
**HUANG, Shu-shun**, Analytic wave functions for atoms, 17: 32796
**HUANG, Tzu-chang**, Cross sections for strange particle production. II., 17: 32920
**HUCEK, H. J.**, Large-size furnaces for heat treating metal assemblies, 17: 32207 (DMIC-Memo-167)
**HUDDLESTON, C. M.**, Differential dose albedo of $\gamma$ rays, 17: 33225
**HUET, Andre**, Nuclear reactor with fuel under spheroidal form, 17: 33296
**HUFFAKER, J. N.**, Induced effects in $\beta$ decay, 17: 33095
**HUG, H.**, Effect of Be contents on Al, 17: 32611
**HUGGETT, R. W.**, Interactions of heavy nuclei with energy $>10^{14}$ev/nucleon, 17: 32893
**HUGGINS, C. M.**, Further NMR studies of polydimethylsiloxanes, 17: 32602
**HUGHES, M. P.**, Spectral observations of solar radio bursts. IV., 17: 32855
**HULSE, E. V.**, Effects of cysteamine and their modification by x irradiation, 17: 31898
**HULUBEI, H.**, Proton scattering by F-19 and Ar-40, 17: 33063
**HULYALKAR, R. K.**, Synthesis of L-arabinose-5-$C^{14}$, 17: 32141
**HUMPHREYS, William G.**, Fluorometric determination of cerous ion, 17: 31996
**HURE, J.**, Electrorefining of nuclear metals, 17: 32499
**HURSH, John B.**, Device to measure Th-228 at natural levels, 17: 31984 (CONF-16-1)
**HUSHFAR, F.**, R-f heating of dense, moving plasma, 17: 33211
**HUSMANN, O. K.**, Contact ionization of Cs on W, 17: 32825
**HUTCHINSON, P.**, Hyper-chain equation of state of hard-sphere gas, 17: 32778
**HUTCHINSON, T. E.**, Electron beam heating in amorphous Nb films, 17: 32489
**HUXTABLE, G.**, Improving duty cycle of Harwell synchrocyclotron, 17: 33132
**HVINDEN, T.**, Cesium-137 in air, Norway, 1957, 17: 32275
**HYATT, E. C.**, Measuring radioactive dusts, 17: 32310
**HYATT, E. C.**, Respirator program for U mills, 17: 32311
**HYDE, E. K.**, Neutron-deficient isotopes of La, 17: 33023

## I

**IBELE, W. E.**, Heat transfer bibliography, 17: 32257
**IGONIN, V. V.**, Distributions of photoneutrons from Bi, Au, and Ta, 17: 33074
**IIJIMA, T.**, Geomagnetically conjugate relationships of giant pulsations,

Antarctica and Iceland, 17: 32867
**IKAWA, Katsuichi,** Oxidation rate of intentionally punctured dummy fuel element, 17: 32527
**ILIESCU, C. C.,** Polar surfaces for nuclear instruments, 17: 32791
**ILYUKHIN, A. V.,** Action of bone marrow transfusions in radiation sickness, 17: 31970
**INGRAM, Albert G.,** Properties of F-48 Nb alloy, 17: 32567 (BMI-X-249)
**INOTO, S.,** Formation of $UC_{1-x}O_x$ and $UC_{1-x}N_x$, 17: 32132
**INDREAS, Gr.,** Ion motion in central cyclotron zone, 17: 33123
**INFELD, L.,** Wave equation of electron in general relativity theory, 17: 32735 (UCRL-Trans-981)
**INGALLS, Ronald B.,** Tritium $\beta$-decay induced reactions in polystyrene fluor, 17: 32152 (CONF-14-21)
**IONESCU, S.,** Organic solvents in cation exchange, 17: 32092
**IONESCU-PALLAS, N. J.,** Zeeman levels in alkali metal atoms. II., 17: 32091
**ISABELLE, D. B.,** Study of giant resonance in O-16, 17: 33052
**ISBIN, Herbert S.,** Introductory nuclear reactor theory, 17: 33266
**ISKENDERIAN, H. P.,** Physics performance of EBWR, 17: 33345
**ISMATOV, E.,** Splitting of deuterons during scattering by nuclei, 17: 33068
**ISRAEL, G.,** Seasonal variations of bomb tritium in rain, 17: 32281
**ITO, Akira,** Platinum–Nb system, 17: 32638
**ITZE, L.,** Hemoaglutination and coagulation after irradiation of dogs, 17: 31953
**IVANITSKAYA, A. F.,** Fast-neutron effect on spleen on white mice, 17: 31946
**IVANOV, V. E.,** Impregnation of graphite with Si in vacuum, 17: 32554
**IVANOV, V. E.,** Magnesium cermets and Mg–Be alloys, 17: 32553
**IVANOV, V. E.,** Uranium-based cermet alloys, 17: 32657
**IVANOV, V. P.,** Properties of polycomponent Li silicate glasses, 17: 32098
**IVANOV-EMIN, B. N.,** Reactions of Sc chlorides with ethylenediamine, 17: 32147
**IVASCU, M.,** Proton scattering by F-19 and Ar-40, 17: 33063
**IVES, Philip T.,** Radiation-induced mutation rates in *Drosophila melanogaster*, 17: 31894
**IWAMOTO, Kozumi,** Reprocessing of $UO_2$-dispersed graphite fuels. II., 17: 32200
**IZUMI, I.,** Solid-state logarithmic amplifier, 17: 32349
**IZYUMOV, Yu. A.,** Theory of neutron scattering in magnetic crystals, 17: 32987

## J

**JACKSON, D. A.,** Isotope shifts in the resonance line of the arc spectrum of Ba, 17: 33062
**JACKSON, Leslie Terence,** Instability in three-phase magnetic amplifier operation, 17: 32342 (UCRL-10855)
**JACOB, K.,** Labile phase of the radiation effect, 17: 31959
**JACQUEMIN, J.,** Water discharge measurement in compact core of FRJ-1, 17: 33372 (JÜL-125-RE)
**JAECH, J. L.,** Prog. rpt. on Zr alloy design, 4–6/63, 17: 32484 (GEAP-4284)
**JAGGI, R. K.,** Role of plasma instabilities in origin of solar flares, 17: 33166
**JAHN, Robert G.,** Plasma pinch as gas accelerator, 17: 33203
**JAHODA, F. C.,** Magnetic field in Scylla I theta pinch, 17: 33178
**JAIN, P. L.,** Production of deuteron, triton and helium by proton interactions in nuclear emulsions, 17: 33091
**JAIN, P. L.,** Proton-nucleon interactions in nuclear emulsion at 28 Bev/c, 17: 32965
**JAKES, D.,** Composition of stoichiometric $UO_2$, 17: 32131
**JAKESOVA, L.,** Fabrication of compacted $UO_2$ pellets, 17: 32555
**JAMES, D. W.,** Vibrational spectra of molten salts, 17: 32041 (ORNL-3413)
**JANAVICIUS, A. (A. I. Yanovichyus),** Center-of-mass motion in particle system, 17: 32930
**JANIK, Jerzy A.,** Neutron scattering by molecular systems, 17: 32986
**JANSEN, C. R.,** Lymphocyte production measured by extracorporeal irradiation, 17: 31852 (BNL-7137)
**JANVIER, J. C.,** Thermal conductivity of $UO_2$ up to 1200°C, 17: 32698
**JARRETT, Steven Michael,** Density measurement applied to alkali metal vapors oriented by optical pumping, 17: 32047 (TID-19198)
**JENKINS, D. J.,** Standardization of pure $\beta$-emitting nuclides, 17: 32413
**JENKINS, E. W.,** $K^-$-p total cross section between 2.7 and 5.2 Bev/c, 17: 32897 (BNL-6962)
**JENKS, Laurence,** Improvements in remote-operating tools, 17: 32231
**JENKS, Laurence,** Improvements in remote-operating tools, 17: 32232
**JENKS, Laurence,** Improvements in remote-operating tools, 17: 32233
**JENKS, Laurence,** Improvements in remote-operating tools, 17: 32234
**JENSEN, Eberhart,** Macroscopic inhomogeneities in solar atmosphere. IV., 17: 32856
**JENSEN, Richard E.,** Colloid absorption band in CsBr, 17: 32043 (TID-19124)
**JERDE, David A.,** Stability of positive column in time-dependent magnetic field, 17: 33142 (D1-82-0218)
**JESSEPH, John E.,** *In vivo* activation in mice of C-12, N-14, and O-16, 17: 31851 (BNL-6989)
**JEVERDAN, Gh. T.,** Shell structure and Roche nuclear density, 17: 33010
**JOHNSON, Benjamin M.,** Spray calcination reactor, 17: 33411
**JOHNSON, C. E.,** Mössbauer effect in compounds of Xe-129, 17: 32089
**JOHNSON, C. E.,** SNAP-8 reactor and shield, 17: 33392
**JOHNSON, Dale E.,** Development of BeO for EBOR, 17: 33366 (GA-4333)
**JOHNSON, J. W.,** Prog. rpt. on materials for nuclear engineering applications, 7/62–6/63, 17: 32488 (TID-19057)
**JOHNSON, John L.,** Hydromagnetic instabilities in multipolar systems, 17: 33175
**JOHNSON, Noah R.,** Nuclear chemistry. II., 17: 32815
**JOHNSON, R. M.,** Cardiovascular disease in irradiated beagles, 17: 31862 (UCD-107(p.50-73))
**JOHNSON, R. M.,** Examination of control and x-irradiated beagles, 17: 31859 (UCD-107(p.13-29))
**JOHNSON, R. M.,** Kennel management and clinical observations, 17: 31858 (UCD-107(p.7-12))
**JOHNSON, R. M.,** Mammary tumors in x-irradiated and control beagles, 17: 31860 (UCD-107(p.30-43))
**JOHNSON, Roy R.,** Stability of positive column in time-dependent magnetic field, 17: 33142 (D1-82-0218)
**JOHNSTON, R. L.,** Triton-induced reactions on B-10, 17: 32997 (CONF-46-79)
**JONES, A. Vallance,** Auroral patches showing strong H lines, 17: 32861
**JONES, Frank C.,** Energy spectrum of galactic electrons, 17: 32886
**JONES, J. K. N.,** Synthesis of L-arabinose-5-$C^{14}$, 17: 32141
**JONES, L. W.,** Elastic scattering of negative pions by protons, 17: 32906 (NP-12990)
**JONES, Llewellyn H.,** $\nu_3$ and $\nu_1$ bands of the $NT_3$ molecule, 17: 32048 (TID-19213)
**JONES, P. B.,** Optical model in nuclear and particle physics, 17: 33108
**JONES, W. H.,** Nuclear and cosmic radiation in ocean, 17: 32718 (NP-12996(p.36-7))
**JOSEPH, D. W.,** Unitary operators in quantum field theory, 17: 32717 (NP-12996(p.29-35))
**JOUSSEAUME, C.,** Diffusion cloud chamber for fast neutrons, 17: 32422
**JOVANOVIC, D.,** Vibratory compaction of $UO_2$ powder, 17: 32552
**JUDD, A. M.,** Neutron flux measurements by resonance activation of foils, 17: 32418
**JUGAKU, Jun,** Ultraviolet spectrum of 3 Centauri A, 17: 32851
**JUNGHANS, Ursula,** Photometric determination of Ce, 17: 32021

## K

**KAC, M.,** Study of several lattice systems, 17: 32764
**KAIPOV, D. K.,** Resonance scattering of $\gamma$ quanta on Cu-65 and Ti-46, 17: 33076
**KAIRAITIS, D.,** Bibliography on binary and ternary systems with BeO, 17: 32560 (AAEC/TM-199)
**KAIRAITIS, D.,** Quantitative measurement of small amounts of He, 17: 31987 (AAEC/Trans-14)
**KAISER, Reinhold,** Nuclear Overhauser effect in analysis of NMR spectra, 17: 32129
**KAJFOSZ, J.,** Beam of polarized neutrons, 17: 32977
**KAKAR, Satya N.,** Suppressor mutations for the isoleucine locus in Saccharomyces, 17: 31821
**KALADE, J. (Yu. A. Kolade),** Center-of-mass motion in particle system, 17: 32930
**KALISH, Y.,** Gamma scintillation spectrometer, 17: 32431

**KALMYKOV, A.**, Reaction $C^{12}(p,p)C^{12m}$, 17: 33043
**KALMYKOV, A.**, Reaction $C^{13}(p,\gamma)$ from 10 to 50 Mev, 17: 33044
**KALMYKOVA, L. P.**, Properties of polycomponent Li silicate glasses, 17: 32098
**KALUDER, John R.**, Continuous-representation theory. II., 17: 32763
**KAMINSKII, V. A.**, Direct nuclear reactions in initial and final states, 17: 33085
**KAMINSKII, V. A.**, Mass transfer in separation of isotopes, 17: 32470
**KANAYA, Koichi**, Electron beam trajectory tracing, 17: 32346
**KANE, J. R.**, Improved noble liquid scintillation counter, 17: 32449
**KANNANGARA, M. L. T.**, Flux of primary cosmic-ray $\alpha$ particles, 17: 32891
**KANTZ, A. D.**, Defects introduced in neutron-irradiated Esaki diodes, 17: 32680
**KAPLAN, Charles H.**, Parameters for background radiation measurements, 17: 32312
**KAPLAN, E. P.**, Thermal and radiation stability of aromatic compounds, 17: 32156
**KAPLAN, Morton**, Recoil range studies of nuclear reactions induced by heavy ions, 17: 33094
**KAPOOR, R. C.**, Polarography of Ce in $Li_2SO_4$, 17: 32099
**KARAYIANIS, N.**, Description of relativistic three-particle emission, 17: 32921
**KARKHANAVALA, M. D.**, Electrical properties of alpha $U_3O_8$, 17: 32562 (AEET/CD/13)
**KARR, Philip R.**, Generalized "cross-correlation" field quantities, 17: 32761
**KARTASHOV, N. V.**, Effect of parameters of cyclotron on accelerated ion bundle, 17: 33124
**KASHUBA, I. E.**, Splitting of deuterons during scattering by nuclei, 17: 33068
**KASYMOV, A. K.**, Formation in $\gamma$-irradiated potato tubers of substances that depress growth and development, 17: 31945
**KATSURA, M.**, Formation of $UC_{1-x}O_x$ and $UC_{1-x}N_x$, 17: 32132
**KATZ, S. A.**, Direct determination of some alkali metal ions, 17: 31998
**KAUFMAN, Joyce J.**, Infrared spectra of some $B^{11}$-labeled diboranes, 17: 32079
**KAUN, Karl-Heinz**, Decay of Tm-168, 17: 33008 (ZFK-PHA-8)
**KAVANAGH, R. W.**, Reaction $He^4(\alpha,\gamma)Be^7$, 17: 33103
**KAWAHATA, Masao**, Low-manganese stainless steels for reactor materials, 17: 32628
**KAWAKATSU, Hisazo**, Electron beam trajectory tracing, 17: 32346
**KAWANO, M.**, Properties of natural radioactivity in atmosphere, 17: 32280
**KAYS, W. M.**, Heat transfer in annular passages, 17: 32255
**KAZES, E.**, Neutral scalar theory with recoil, 17: 32899 (CONF-46-80)
**KAZNACHEEVA, K. F.**, Reciprocal system of Na and K pyrophosphates and fluorides, 17: 32114
**KECHIN, V. V.**, Galvanomagnetic effects and electron spectrum of graphite, 17: 32641
**KEDEM, Drora**, Measurements of gyromagnetic ratios, 17: 32771
**KEE, Herbert**, Thoria-dispersed Ni, 17: 32501
**KEITH, R. L. G.**, Determination of Pu-239, Pu-238 and Pu-236, 17: 32992 (AWRE-O-59/63)
**KELLER, C.**, Ternary oxides of Nb and Ta, 17: 32100
**KELLER, Donald L.**, Prog. rpt. on UN, 10–12/62, 17: 32483 (BMI-X-10027)
**KELLER, O. L., Jr.**, Identification of complex ions of Nb(V) in HF, 17: 32070
**KELSEY, C. A.**, Polarization of neutrons from $Be^9(p,n)B^9$ reaction, 17: 33053
**KENNEY, G. N.**, Thermoluminescent dosimeter reading system, 17: 32448
**KENNEY, Gordon N.**, Prog. rpt. on thermoluminescent radiation dosimetry, 17: 32402 (TID-19112)
**KENSCHKI, Ulrich K.**, Afterloading in radiation therapy, 17: 31878
**KENT, William Charles Leonard**, Improvements in reactor fuel elements, 17: 33284
**KENT, William Charles Leonard**, Improvements in reactor fuel elements, 17: 33285
**KERIMOV, I. G.**, Thermal conductivity of A(III) and B(V) compounds, 17: 32629
**KERN, J. W.**, Magnetic field of earth and planets, 17: 32879
**KERNCHEN, W.**, Trap properties of electroluminescent ZnS phosphors, 17: 32834
**KERNS, Quentin A.**, Pulse synthesizing generator, 17: 32394
**KERREBROCK, J. L.**, Insulator boundary layers in MHD channels, 17: 33201
**KERSTEN, J. Antonius Hendrikus**, Controlling power of suspension reactor when diminishing load, 17: 33295
**KHACHATURYAN, M. N.**, Measurement of Panofsky ratio by coincidences, 17: 32947
**KHALATNIKOV, I. M.**, Regge poles in quasiclassical potential well, 17: 32956
**KHAN, M.**, Design and operating experience with power reactors, 17: 33340
**KHEIFETS, Yu. B.**, Blood formation and viability in irradiated mice, 17: 31941
**KHIEN, Fom Zui**, Resonance $\gamma$ absorption in Ba, Sr, and Ca stannites, 17: 32107
**KHLEBNIKOV, G. I.**, Triple fission of Pu, 17: 33079
**KHRIPLOVICH, I. B.**, Restrictions on asymptotic cross sections imposed by Regge poles, 17: 32957
**KHUDZINSKII, L. L.**, Data on pulse shape induced in drill holes, 17: 32271
**KHURANA, C. S.**, Half life of first excited state of I-129, 17: 33041
**KIDD, J.**, Interactions of heavy nuclei with energy $>10^{13}$ev/nucleon, 17: 32893
**KIEFFER, K.**, Niobium–Ta alloys for impregnation, 17: 32495
**KIELY, Joseph M.**, Radiochromium-labeled lymphocytes in the rat, 17: 31917
**KIESS, Norman H.**, Preparation of rare-earth halides, 17: 32087
**KIKUCHI, Yasuo**, Radiolysis of ferrous sulfate solutions. I., 17: 32162
**KIKUCHI, Yasuo**, Radiolysis of ferrous sulfate solutions. II., 17: 32163
**KILB, R. W.**, Electron temperature in $\theta$ pinch determined from impurity line radiation, 17: 33214
**KIM, Y. W.**, Electron paramagnetic resonance absorption studies of neutron-irradiated $\alpha,\alpha$-diphenyl-$\beta$-picryl hydrazine, 17: 32756
**KIMEL, L. R.**, Gamma field of beam from point source of Cs-137 or Co-60, 17: 32923
**KIMURA, Hirozo**, Platinum–Nb system, 17: 32638
**KIMURA, Jotaro**, Studies on Al–U alloys, 17: 32500
**KING, E. G.**, Heat capacities of sesquioxides of Sc and Ce, 17: 32031 (BM-RI-6245)
King, Lu
*see Lu, King*
**KINGSLEY, P. S.**, Welding of stainless steel, 17: 32540 (TID-19161)
**KINO, G. S.**, Harmonic generation in a plasma discharge, 17: 33162
**KIRKHAM, W.**, Chemistry of Re and Tc, 17: 32137
**KIRKPATRICK, Craig C.**, Magnetic investigation of dilute solid solutions of 4f and 3d transition metals, 17: 32651
**KISHBAUGH, A. A.**, Prog. rpt. on processing reactor fuels, 1–3/63, 17: 32192 (DP-839)
**KISHBAUGH, Albert A.**, Extraction behavior of Zr, 17: 32191 (DP-818)
**KISHKIN, S. T.**, Self-diffusion of Mo in Mo–Zr alloys, 17: 32593
**KLAUDER, John R.**, Continuous-representation theory. I., 17: 32762
**KLECKER, R. W.**, Future of nuclear superheat and reheat, 17: 33353
**KLEIN, M. W.**, High-frequency electrostatic instabilities in plasma, 17: 33195
**KLEIN, Melvin P.**, Enhancement of signal-to-noise ratio by continuous averaging, 17: 32363
**KLEIN, W.**, Temperature coefficients and saturation of luminescence of ZnS single crystals, 17: 32833
**KLEMA, E. D.**, Analysis of directional-correlation data, 17: 33031
**KLEMPERER, William**, Geometry of $Li_2O$ by electric deflection, 17: 32030 (AROD-006.9)
**KLEPFER, H. H.**, Hydrogen uptake of Zr alloys, 17: 32519
**KLEPFER, H. H.**, Prog. rpt. on Zr alloy design, 4–6/63, 17: 32484 (GEAP-4284)
**KLEPFER, H. H.**, Zirconium–Nb binary alloys. I., 17: 32524
**KLEPFER, H. H.**, Zirconium–Nb binary alloys. II., 17: 32525
**KLIMENKO, A. A.**, Leukopenia in Ra therapy, 17: 31904
**KLING, H. G.**, Physical properties of sintered $UO_2$ bodies, 17: 32585
**KLINGER, D.**, Properties of CsBr(Tl) and RbI(Tl) crystals, 17: 32444
**KLUBES, P.**, Problems of tritiation of S-(1,2-dichlorovinyl)-L-cysteine, 17: 32143
**KLYUCHAREV, A. P.**, Elastic scattering of deuterons on Cr and Zn

isotopes, 17: 33071
**KLYUCHAREV, A. P.,** Formation of isomer and ground states of nuclei in (p,n) reaction, 17: 33072
**KLYUCHAREV, A. P.,** Reaction (p,α) at 20 Mev, 17: 33070
**KNISELEY, Ralph M.,** Sulfur-35 studies in man, 17: 31903
**KNIZHNIKOV, V. A.,** Effect of stable Sr on metabolism and uptake of Sr-90, 17: 31831 (JPRS-19626)
**KNOBLOKH, V.,** Separation of rare-earth elements by electrophoresis, 17: 32196 (UCRL-Trans-973)
**KOBAYASHI, Fumiaki,** Reprocessing of $UO_2$-dispersed graphite fuels. II., 17: 32200
**KOCH, B.,** Selenium purity examinations by activation analysis, 17: 32020
**KOCH, H.,** Selenium purity examinations by activation analysis, 17: 32020
**KOCH, R. C.,** Analysis and evaluation of fallout radioactivity, 17: 32288 (NSEC-91)
**KOCHEMIROVSKII, A. S.,** Isotopic composition after emission spectra of molecules, 17: 32023
**KOCHENDORFER, Albert,** Microstructure changes in irradiated alpha Fe, 17: 32673
**KOCHERGINA, N. N.,** Properties of polycomponent Li silicate glasses, 17: 32098
**KOCHIN, G. G.,** Deposits of U in coals, 17: 32277
**KOEHLER, W.,** Determination of fast neutron dose by threshold detectors, 17: 32294 (CEA-tr-A-1221)
**KOEN, J. W.,** Track location in multi-wire spark counters, 17: 32443
**KOGAN, V. S.,** Isotopic effect in volumes N isotope unit cells, 17: 32106
**KOKUBUN, S.,** Geomagnetically conjugate relationships of giant pulsations, Antarctica and Iceland, 17: 32867
**KOLBIN, H. I.,** Solid Ru tetrachloride, 17: 32122
**KOLENDOVSKII, M. G.,** Impregnation of graphite with Si in vacuum, 17: 32554
**KOLENKOVA, M. A.,** Precipitation of $Zr(SO_4)_2$ from $H_2SO_4$ solutions, 17: 32077
**KOLINOVA, I. A.,** Inhomogeneity of magnetic fields for NMR spectrometer, 17: 32367
**KOLOMIETS, L. D.,** Impregnation of graphite with Si in vacuum, 17: 32554
**KOLOMIITSEVA, I. K.,** Free radicals in lipids of liver and spleen of irradiated rats, 17: 31927
**KOLTYPIN, E. A.,** Mass-flow function of Ni-62, Se-80, Cd-114, and Sn-118, 17: 33027
**KOLYCHEV, B. S.,** Heat release from high-activity solid substances, 17: 33407
**KOMAREK, K. L.,** Lattice parameters of Hf–O alloys, 17: 32630
**KOMISSAROVA, L. N.,** Preparation and properties of Sc nitrates, 17: 32172
**KOMISSAROVA, L. N.,** Solubility of $Sc(NO_3)_3$ and $ScOH(NO_3)_2$, 17: 32115
**KOMPANEETS, A. S.,** Model of charged particle with angular momentum, 17: 32961
**KONDRATENKO, A. M.,** Theory of plasma waveguide, 17: 33185
**KONSTANTINOVA, A. I.,** Absorption of H by Ce–Mg alloys, 17: 32643
**KONSTANTINOVA, V. V.,** Physico-chemical changes in DNA by *in vivo* Pu-239, 17: 31923
**KONSTANTINOVA, V. V.,** Therapeutic action of highly polymerized DNA in radiation sickness, 17: 31973
**KONZAK, C. F.,** Analysis of radiation-induced genetic damage in seeds, 17: 31869
**KONZAK, C. F.,** Production of radiation-induced genetic effects in plants, 17: 31951
**KOOY, P.,** Zone-melting of oxides, 17: 32590
**KOPECKY, J.,** Beam of polarized neutrons, 17: 32977
**KOPROWSKI, Hilary,** Effects of $D_2O$ upon Simian $Virus_{40}$, 17: 31837
**KORKISCH, Johann,** Prog. rpt. on ion exchange separation of U and Th, 4/63, 17: 32194 (TID-19068)
**KOROLEV, A. M.,** Coulomb interaction in (d,p) reaction, 17: 33067
**KOSKI, W. S.,** Infrared spectra of some $B^{11}$-labeled diboranes, 17: 32079
**KOSTIC, E.,** Procedure for $UO_2$ sintering, 17: 32658
**KOSTYRKO, I. I.,** Analytical properties of amplitudes of inelastic processes, 17: 32942
**KOSZELSKI, J.,** Determination of Th concentration using nuclear emulsion plates, 17: 31988 (CEA-tr-A-1197)
**KOTHMANN, R. E.,** Design of superconducting magnet, 17: 32224
**KOTOVA, E. S.,** Ophthalmological changes in acute radiation sickness, 17: 31978
**KOU, Tsing-tsuan,** Analytic wave functions for atoms, 17: 32796
**KOUTS, H.,** Beam-tube design for high-flux beam reactor, 17: 33379
**KOUTS, H.,** Reactor physics, 17: 31794 (BNL-782(p.1-17))
**KOVAC, B. J.,** G-M counters as switching elements, 17: 32425
**KOVRIZHNYKH, L. M.,** Oscillations of low-pressure inhomogeneous plasma, 17: 33189
**KOZHEVNIKOV, D. A.,** Diffusion characteristics of moderator function of temperature, 17: 32976
**KOZIK, B.,** Exact solution of slowing-down equation for fast neutrons, 17: 32983
**KOZINETS, G. I.,** Action of bone marrow transfusions in radiation sickness, 17: 31970
**KOZIOL, J. J.,** Beryllium diffusion barrier coatings, 17: 32574 (PWA-2184)
**KOZLOV, V. F.,** Two-electron charge of low-energy protons, 17: 33077
**KOZLOWSKII, Mieczyslaw F.,** Guiding-center approximation in diamagnetic ring current, 17: 32863
**KRAMER, D.,** Transformation $\gamma$–$\gamma'$ in U–Mo, 17: 32605
**KRASYUKOVA, L. I.,** Action of bone marrow transfusions in radiation sickness, 17: 31970
**KRAUSE, Renate,** Electron microscopy of irradiated sintered $UO_2$ pellets, 17: 32670 (ZFK-WF-21)
**KRAUSHAAR, J. J.,** Decay of V-48, 17: 33056
**KRAVTSOV, N. V.,** Spin induction in electron paramagnetic resonance, 17: 32754
**KRENZ, J. H.,** Harmonic generation in a plasma discharge, 17: 33162
**KRETCHMAR, A. L.,** Increase in lysozyme activity in kidneys of irradiation chimeras, 17: 31919
**KRIMM, S.,** Infrared spectra for PVC and deuterated analogs, 17: 32606
**KRISEMENT, Otto,** Structure analysis for Fe-, W-, and Cr carbides, 17: 32057
**KRISS, E. E.,** Solubility of rare earth dialkyl phosphates, 17: 32148
**KRISS, E. E.,** Solubility of Nd di-n-butyl phosphate, 17: 32149
**KRITCHEVSKY, David,** Effects of $D_2O$ upon Simian $Virus_{40}$, 17: 31837
**KRIVETS, G. E.,** Reaction (p,α) at 20 Mev, 17: 33070
**KRMPOTIC, F.,** Beta spectroscopy with solid-state detectors, 17: 32421
**KROHMER, J. S.,** Recording of scintillation scan data, 17: 32351
**KROLL, H.,** Manufacture of $UO_2$ fuel elements, 17: 33247
**KRUSE, F. H.,** Preparation of ammonium U(IV) and ammonium Pu(IV) fluorides, 17: 32072
**KRYAKOVSKII, Yu. V.,** Influence of rare earth metals on fused Fe, 17: 32598
**KRYAKOVSKII, Yu. V.,** Solubility of H in liquid Fe, 17: 32597
**KRYUKOVA, O. N.,** Absorption of H by Ce–Mg alloys, 17: 32643
**KU, Fu-nien,** Green tensor functions of electromagnetic field, 17: 32799
**KU, Fu-nien,** Operator in electromagnetic theory, 17: 32798
**KU, Yung-Nien,** Calculations of helically symmetric magnetic fields, 17: 32797
**KUBAREVA, M. M.,** Blood proteins and riboflavin metabolism during Ra therapy, 17: 31907
**KUCHIN, V. D.,** Theory of interaction of radiation with a solid, 17: 32674
**KUDRYASHOV, Yu. B.,** Efficacy of cysteamine protection of mice, 17: 31967
**KULICHENKO, V. V.,** Behavior of radioisotopes incorporated in glass blocks, 17: 33404
**KULICHENKO, V. V.,** Heat release from high-activity solid substances, 17: 33407
**KULYUKIN, M. M.,** Formation of mesic He in mixture of He and H, 17: 33080
**KUMP, P.,** Low-lying states in Al-26, 17: 33057
**KUNI, F. M.,** Transition amplitudes of creation of more than two particles, 17: 32944
**KUNZ, W. E.,** Half-lives of Cs-137 and Co-60, 17: 32719 (NP-12996(p.38-42))
**KURIAKOSE, A. K.,** Kinetics of reaction of F with Zr carbide and Zr diboride, 17: 32130
**KURODA, P. K.,** Fallout of bomb-produced Ce isotopes, 17: 32298
**KUSHAKOVSKII, M. S.,** Mechanism of action of antiradiation agents, 17: 31833
**KUZIMINOV, A. V.,** Resonance scattering of γ quanta on Cu-65 and Ti-46, 17: 33076
**KUZIN, A. M.,** Formation in γ-irradiated potato tubers of substances that depress growth and development, 17: 31945

**KUZ'MINSKAYA, G. N.**, Sorption properties of cells and tissues in x-irradiated mice, 17: 31924
**KUZNETSOV, V. I.**, Mechanism of action of antiradiation agents, 17: 31833
**KUZNETSOV, V. V.**, Data on pulse shape induced in drill holes, 17: 32271
**KUZUU, H.**, Precipitation of He during annealing of Al–Li alloy, 17: 32603
**KVASNIKOVA, L. N.**, Reception of ionizing radiation by organism, 17: 31908
**KYCIA, T. F.**, $K^-$-p total cross section between 2.7 and 5.2 Bev/c, 17: 32897 (BNL-6962)

# L

**LACINA, J.**, Motion of charged particle in magnetic mirror, 17: 33165
**LACROUTE, M. P.**, Abundances of isotopes synthesized by fast-neutron capture, 17: 32869
**LADENBAUER-BELLIS, Inge-Maria**, Excitation functions for Li-6 induced reactions on Au-197, 17: 33038
**LADU, M.**, Response to fast neutrons of $BF_3$ counter, 17: 32432
**LAGACHE, M. P.**, Prog. rpt. on Pu recycle, 4–6/63, 17: 33240 (GEAP-4303)
**LAGEDROST, John F.**, Radiation stability of UN, 17: 32660 (BMI-1638)
**LAHR, T. N.**, Ceramic carrier for radioisotopes, 17: 32327
**LAIKIN, Milton**, New double-beam fluorometer, 17: 32364
**LAINER, A. I.**, Precipitation of $Zr(SO_4)_2$ from $H_2SO_4$ solutions, 17: 32077
**LALLEMANT, Claude**, Improvements in devices for identifying radioactive elements, 17: 32462
**LAM, D. J.**, Application of NMR to transition metals, 17: 32569 (CONF-54-1)
**LAMB, W. A. S.**, High-current linear induction accelerator for electrons, 17: 33119 (UCRL-7408)
**LAMBERT, P. D.**, Iodine-131 in bovine thyroids following atmospheric fall-out, 17: 32313
**LAMBERTS, H. B.**, X-ray reactions with regard to chemoprotection. VII., 17: 31900
**LAMBERTSON, Glen R.**, High-intensity phenomena at the Bevatron, 17: 33121 (UCRL-10867)
**LAMI, H.**, Light impulse generators in the nanosecond region, 17: 32212
**LANDRY, Peter**, Paramagnetic-antiferromagnetic transition of Dy, 17: 32748
**LANE, Kea**, Comparison of natural inulin with its radioactive derivatives, 17: 31920
**LANG, Donald W.**, High angular momentum cut-off in nuclear level densities, 17: 32999 (CONF-62-7)
**LANGE, F.**, Investigation of superconducting $Nb_3Sn$, 17: 32615
**LANGKAU, R.**, Properties of CsBr(Tl) and RbI(Tl) crystals, 17: 32444
**LANGLEY, R. A.**, Production of slow electrons and positive ions in He, Ne, Ar, $H_2$, $N_2$, $O_2$ and CO by helium ions, 17: 32731 (TID-19137)
**LANNING, W. D.**, Reduction of thermal activation rates to continuous spectrum, 17: 33245 (WAPD-T-1582)
**LANZL, L. H.**, Radiation therapy with high-energy electrons, 17: 31870
**LAPKIN, Yu. A.**, Dependence of occurrence of lethal mutation in Drosophila spermatogenesis on neutron dose, 17: 31936
**LA SALLE, R. A.**, Alpha particle breakup induced by inelastic scattering of $\alpha$ particles from C-12 and F-19, 17: 33097
**LATNER, H.**, Variable coincidence unit HASL-type TL-9, 17: 32409
**LATORRE, V.**, Charged-particle detector for magnetic analyzers, 17: 32428
**LAUGHTON, P. M.**, Solvolysis in light and heavy water. V., 17: 32063
**LAUSTRIAT, G.**, Light impulse generators in the nanosecond region, 17: 32212
**LAVAKARE, P. J.**, Multiple Coulomb scattering in nuclear research emulsions, 17: 32907 (NYO-10271)
**LAVRENCHIK, V. N.**, Atmospheric contamination over Atlantic Ocean in 1961, 17: 31844
**LAY, C.**, Absolute age of old formations of Kasai basement, 17: 32269
**LAYZER, David**, Preface to cosmogony. I., 17: 32853
**LAZAREVA, L. E.**, Distributions of photoneutrons from Bi, Au, and Ta, 17: 33074
**LAZUKIN, V. N.**, Spin induction in electron paramagnetic resonance, 17: 32754
**LEACH, Leonard J.**, Laboratory test chamber for studying air-borne materials, 17: 32292 (UR-629)
**LEAVER, E. W.**, Some uses of radioisotopes in automation, 17: 32331
**LEBEDEV, A. N.**, Bioelectric reaction of rabbit brain cortex to irradiation, 17: 31934
**LEBOULEUX, P.**, Measurement of activity of $\beta$-emitting gases using 36? ionization chamber, 17: 32398 (CEA-2215)
**LEBOVITZ, Norman R.**, Convective instability of gaseous masses, 17: 32743
**LEBRUN, P.**, Treatment and packaging of solid waste irradiated in pile, 17: 33410
**LEDENT, D.**, Absolute age of uraniferous minerals of Katanga and Northern Rhodesia, 17: 32265
**LEDENT, D.**, Absolute age of old formations of Kasai basement, 17: 32269
**LEDERHAUSEN, M.**, Isotope exchange between $H_2S$ and sulfides, 17: 32138
**LEE, A. R.**, Ionization by protons in range 100 to 450 kev, 17: 32790
**LEE, D.**, Modified Bayard-Alpert gage with x-ray suppression, 17: 32366
**LEE, Linda**, Electrochemical characteristics of rare earth and Y metals, 17: 32034 (CONF-20-22)
**LEE, Roberto**, Vapor phase nitration of propane: effect of $\gamma$ radiation and temperature, 17: 32175
**LEFEVRE, J.**, Storing highly radioactive waste, 17: 33401
**LEFRANCOIS, J.**, Recoil protons from e-p scattering at 950 Mev, 17: 32905 (LAL-1072)
**LEI, Chao-tsu**, Radiation effects on chromosomal rearrangements in spermatogenesis, 17: 31950
**LEIMDOERFER, M.**, Sensitivity of $BF_3$ proportional counter, 17: 32445
**LEIPUNSKII, O. I.**, Gamma field of beam from point source of Cs-137 or Co-60, 17: 32923
**LEMENT, B. S.**, Substructure and mechanical properties of refractory metals, 17: 32565 (ASD-TR-61-181(Pt.III))
**LENN, P. D.**, Three-fluid nonequilibrium plasma accelerators. II., 17: 33210
**LE PAIR, C.**, Melting curve of He-4, 17: 32780
**LEPESTKIN, A. I.**, Distributions of photoneutrons from Bi, Au, and Ta, 17: 33074
**LE ROY, J. L.**, Diffusion cloud chamber for fast neutrons, 17: 32422
**LERSMACHER, B.**, Sintering of Hf, Zr, and Ta carbides, 17: 32583
**LES, F.**, Isotope shift in uv lines of Zn II, 17: 33011
**LES, Z.**, Isotope shift in uv lines of Zn II, 17: 33011
**LESSING, I. J.**, Track location in multi-wire spark counters, 17: 32443
**LE TRAON, J. Y.**, Analysis of Fe and lime in drill core samples, 17: 32016
**LEUNG, E. Y.**, Heat transfer in annular passages, 17: 32255
**LEVIN, E. M.**, Polymorphism of $ABO_3$-type rare earth borate solid solution, 17: 32124
**LEVINE, E. P.**, Symmetry splitting of equivalent sites in oxide crystals, 17: 32607
**LEVINSON, E. S.**, Boron-containing stainless steel for reactors, 17: 33261
**LEVSHIN, V. I.**, Therapeutic effect of Na chlorophyllin on radiation sickness, 17: 31976
**LEW, D. E.**, Stainless steel-sheathed $UO_2$ fuel elements, 17: 32662 (CRFD-1132)
**LEWANDOWSKI, A.**, Selective ion change. II., 17: 32195 (KFK-tr-130)
**LEWIN, Seymour Z.**, Apparatus for determining particle size, 17: 32842
**LEWINS, Jeffery**, Weighing functions of reactor physics, 17: 33255
**LEWIS, Clifford J.**, Uranium ore-carbonate leach process, 17: 32188
**LEWIS, D. T.**, Determination of As by oxygen flask technique, 17: 32003
**LEWIS, J. B.**, Chemical factors influencing the thermal oxidation of nuclear graphite, 17: 32128
**LEWIS, William Bradley**, Differential calorimeter for radiation-induced power, 17: 32333 (CONF-39-53)
**LI, Kuang-ting**, Operation of neutron diffractometers, 17: 32368
**LI, Zheng-wu**, Injection of particles in magnetic mirror system, 17: 33197
**LIBBY, W. F.**, Moratorium tritium geophysics, 17: 32758
**LIBINZON, R. E.**, Therapeutic action of highly polymerized DNA in radiation sickness, 17: 31973
**LIBOFF, Richard L.**, Relaxation phenomena in plasmas, 17: 33174
**LICHTY, Robert E.**, Gamma spectroscopy on the production line, 17: 32812
**LIDOFSKY, Leon J.**, Utilization of multiparameter analyzers in nuclear physics, 17: 32348
**LIEBL, Helmut J.**, Ion source for solid materials, 17: 32389

**LIEBMANN, B.,** Manufacture of $UO_2$ fuel elements, 17: 33247
**LIEBMANN, B.,** Manufacture and use of UC for fuel elements, 17: 33248
**LIEMOHN, Harold B.,** Thermal cutoffs of whistler mode of propagation, 17: 33143 (D1-82-0229)
**LIEN, K. P.,** Halden Heavy Water Reactor—operation with core I, 17: 33347
**LIENARD, G.,** Catalysis by irradiation in presence of non-metallic solids, 17: 32178
**LIETZ, G. P.,** Polarization in neutron-deuteron elastic scattering, 17: 32935
**LIEWERS, P.,** Global pile oscillator for Rossendorf Reactor, 17: 33380
**LIGHTOWLERS, E. C.,** Analysis of diamonds by neutron activation analysis, 17: 31995
**LIKHTER, A. I.,** Galvanomagnetic effects and electron spectrum of graphite, 17: 32641
**LILLEGRAVEN, A.,** Cesium-137 in air, Norway, 1957, 17: 32275
**LILLICRAP, S. C.,** Distribution of energy in extensive air showers, 17: 32890
**LILLIE, A. B.,** Winter rail-lubricant study, 17: 32326
**LIMA, Fausto W.,** Determination of gamma isomer in hexachlorocyclohexane by isotope dilution, 17: 32029
**LINDAUER, R. B.,** MSRE design data sheets, 17: 33375 (ORNL-TM-638)
**LINNETT, J. W.,** Mass spectrometer for studying chemical reactions, 17: 32360
**LINNETT, J. W.,** Mass spectrometric sampling, 17: 32361
**LINNETT, J. W.,** Wave functions for the H molecule and molecule ion, 17: 32767
**LIPETS, T. V.,** Properties of Li silicate glasses, 17: 32097
**LIPKIN, Harry J.,** Features of the Mössbauer effect. III., 17: 32056
**LIPNIK, P.,** First excited states (2+) of Yb-170, Os-186, and Os-188, 17: 33015
**LIPPINCOTT, Stuart W.,** *In vivo* activation in mice of C-12, N-14, and O-16, 17: 31851 (BNL-6989)
**LITHERLAND, A. E.,** Negative ion production from beams of 35–200 kev positive ions, 17: 32838
**LITTLE, M. S.,** Wave equation of electron in general relativity theory, 17: 32735 (UCRL-Trans-981)
**LITZ, Lawrence M.,** Oxidation of $B_4C$ by air, $H_2O$, and air–$H_2O$ mixtures, 17: 32523
**LIU, Tsu-t'ung,** Radiation effects on chromosomal rearrangements in spermatogenesis, 17: 31950
**LIVEY, D. T.,** Fabrication, properties, and irradiation stability of dispersion-type fuels, 17: 33262
**LLOYD, P. H.,** Action of $\gamma$ rays on Na deoxyribonucleate in solution. IV., 17: 31912
**LLOYD, R. D.,** Differential accumulation of I-131 from local fallout, 17: 31848
**LOEWENSTEIN, Paul,** Extrusion of Be, 17: 32546
**LOFGREN, Edward J.,** Bevatron improvements, 17: 33120 (UCRL-10866)
**LOFSTROM, James E.,** Plasma constituents produced by whole-body irradiation, 17: 31875
**LOGAN, S. R.,** Decomposition of alkali metal nitrates, 17: 32169
**LOINGER, A.,** New concept of representation of Lie algebra, 17: 32478
**LOJKO, M. S.,** Nonlinear transverse waves in plasmas, 17: 33199
**LOKAN, K. H.,** Nanosecond neutron time-of-flight system, 17: 33032
**LOMBARDI, C.,** Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)
**LOMBARDI, C.,** Critical heat flux data for flow of steam–water mixtures, 17: 32245 (EURAEC-671)
**LONG, G.,** Emission of Xe-133 from irradiated $UO_2$, 17: 32563 (AERE-R-4347)
**LONIUS, Anton,** Dependence of gas diffusion coefficient on the mixing ratio, 17: 32052 (AEC-tr-5938)
**LONSDALE, H. K.,** Thermal stability studies of graphite–matrix fuel systems, 17: 32570 (GA-2880)
**LOSEV, V. V.,** Radiochemical studies of electrode processes on amalgams, 17: 32642
**LOTHROP, J.,** Studies of fluid mechanics using MHD generator, 17: 33212
**LOUIS, J. F.,** Studies of fluid mechanics using MHD generator, 17: 33212
**LOURENS, W.,** Gamma ray transitions in Cl-35, 17: 33059
**LOVAAS, Arvin,** Device to measure Th-228 at natural levels, 17: 31984 (CONF-16-1)
**LOVBERG, R. H.,** Acceleration of plasma by displacement currents, 17: 33206
**LOVBERG, R. H.,** Physical processes in coaxial plasma gun, 17: 32225
**LOVE, W. J.,** Nut-clamp seating geometries in connector couplings for NPR, 17: 33362 (HW-71229)
**LOVELL, G. H. B.,** Synthesis of UC and $UC_2$ from urano-uranic oxide, 17: 32133
**LOW, Charles A., Jr.,** Direct nuclear electrogenerator cells, 17: 33391
**LOW, Charles A., Jr.,** Radioisotope electrostatic propulsion system, 17: 33390
**LOWELL, A. F.,** Forecast of trends in U costs, 17: 32186
**LOYSEN, P.,** Fallout protection in structures, 17: 31804 (WT-1462)
**LU, King (Lu King),** Problems of photo-multiplier tubes, 17: 82451
**LU, Yu-ching,** Power supply for electrostatic analyzer, 17: 32370
**LUDBROOK, C. A.,** Standardization of pure $\beta$-emitting nuclides, 17: 32413
**LUDFORD, G. S. S.,** Motion of non-conducting sphere through conducting fluid in magnetic cross-field, 17: 32783
**LUDFORD, G. S. S.,** Motion of sphere through conducting fluid in presence of magnetic field, 17: 32784
**LUEBELSMEYER, K.,** Photoproduction of $\pi^+$ mesons with H, 17: 32964
**LUJANAS, V. (V. Luyanas),** Production of tritium in the atmosphere, 17: 32887
**LUKOVNIKOV, Yu. D.,** Structure and properties of Mg–Th alloys, 17: 32596
**LULING, H.,** Experiences with 31-Mev betatron, 17: 32609
**LUSK, E. C.,** Design of shipping casks for irradiated fuel elements, 17: 32303
**LUZHNOVA, M. A.,** Spectral analysis of Ta and Nb, 17: 32025
**LYAKISHEV, N. P.,** Reduction of Nb concentrates by C, 17: 32492
**LYNCH, M. D.,** Stress analysis of HNPF loading-face shield, 17: 33251
**LYNESS, J. N.,** Neutron-deuteron doublet scattering length. I., 17: 32937
**LYONS, M. F.,** Failures of $UO_2$ swaged fuel rod, 17: 32664 (GEAP-4197)
**LYUBIMOV, G. A.,** Calculations of a boundary on dielectric plane, 17: 32781

# M

**MAC DONALD, D. K. C.,** Electron and phonon scattering. II., 17: 32785
**MAC KENZIE, D. J.,** Thermocouples for high gas temperature measurement, 17: 32644
**MAC DONALD, R. D.,** Stainless steel-sheathed $UO_2$ fuel elements, 17: 32662 (CRFD-1132)
**MAC FARLANE, George,** Simulation of high-energy penetrating radiations, 17: 32884 (AEDC-TDR-63-118)
**MACHEREZ, B.,** Generation of pseudo-random gating impulse, 17: 32344 (AEC-tr-5901)
**MAC DONALD, I. P. L.,** Steam/water mixtures flowing in heated annulus, 17: 32260
**MAC KENZIE, K. R.,** Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)
**MADER, Charles L.,** Detonation properties of condensed explosives, 17: 32039 (LA-2900)
**MADHAVAN, T. R.,** Research on U mineral beneficiation. II., 17: 32185
**MAENNER, W.,** Neutron moderation in ice at 90°K, 17: 32989
**MAGRANE, W. G.,** Ophthalmoscopic findings in experimental beagles, 17: 31861 (UCD-107(p.44-9))
**MAHADEVAPPA, D. S.,** ESR spectra of $\gamma$-irradiated thiosulfate, 17: 32746
**MAHAJAN, M. D.,** Address logic of kicksorter employing ADC, 17: 32437
**MAHAN, G. D.,** Afterloading in radiation therapy, 17: 31878
**MAI, Roland,** Zirconium effect in Al alloys, 17: 32591
**MAIER, R. J.,** Proton-neutron damage correlation in semiconductors, 17: 32678
**MAIER-LEIBNITZ, H.,** Use of neutron optical devices on beam-hole experiments, 17: 32981
**MAIYA, P. S.,** Metallographic etching by monoenergetic ion bombardment, 17: 32505
**MAJOR, J. K.,** Optimum channel width for single-channel analysis, 17: 32429
**MAJUMDAR, K. K.,** Research on U mineral beneficiation. I., 17: 32184
**MAJUMDAR, K. K.,** Research on U mineral beneficiation. II., 17: 32185
**MAK, A. A.,** Four-level optical generator, 17: 32804

**MAKSIMENKO, A. S.,** Transformation of hemopoietic cells in irradiated dogs, 17: 31969
**MAKSIMENKO, V. I.,** Magnesium cermets and Mg–Be alloys, 17: 32553
**MALCIC, S. S.,** High-temperature reaction in $UO_2$–$TiO_2$ system, 17: 32656
**MALHKH, V. D.,** Spectral analysis of Ta and Nb, 17: 32025
**MALINOWSKI, R.,** Concrete shielding for Nahal Soreq reactor, 17: 33378
**MALM, J. G.,** Mössbauer effect in compounds of Xe-129, 17: 32089
**MALMSKOG, S.,** Sensitivity of $BF_3$ proportional counter, 17: 32445
**MALTSEV, M. V.,** Properties of Mg–Th–Mn system, 17: 32595
**MAL'TSEV, V. F.,** Titration of Fe(2+) by Ce(IV) sulfate, 17: 32024
**MALTSEV, V. M.,** Cross sections for strange particle production. II., 17: 32920
**MAMALADZE, Yu. G.,** Stability of rotation of superfluid liquid, 17: 32808
**MAMURO, Tetsuo,** Studies on fallout particles. III., 17: 32302
**MANDL, Anita M.,** Radiosensitivity of oocytes at different stages of maturation, 17: 31913
**MANDL, F.,** Resonant electron scattering by atoms, 17: 32788
**MANFRASS, Peter,** Lithium-glass scintillators for detection of neutrons, 17: 32405 (ZFK-RN-19)
**MANFREDI, P. F.,** Precisions in operation of analog-to-digital conversion, 17: 32408
**MANKUS, T. G.,** Reactivity of animals subjected to radiation, 17: 31974
**MANN, L. G.,** Electrons trapped in the earth's magnetic field following nuclear bursts, 17: 32845 (UCRL-7309(Rev.I))
**MANNING, David C.,** Determination of Al by atomic absorption spectrophotometry, 17: 32028
**MANNO, P. J.,** Radiation-initiated polymerization of fluoromonomers. II., 17: 32179
**MANOJLOVIC, L. M.,** High-temperature reaction in $UO_2$–$TiO_2$ system, 17: 32656
**MANOWITZ, B.,** Radiation, 17: 31796 (BNL-782(p.44-50))
**MANTESCU, Constanta,** Tritiation of aromatics, 17: 32142
**MANUEL, S.,** Biological effect of localized irradiation, 17: 31883
**MARADUDIN, A. A.,** Mössbauer effect for an impurity nucleus. I., 17: 33096
**MARCHAND, Frederic E.,** Electrothermal arc-jet propulsion systems, 17: 32219
**MARCHESSAULT, R. H.,** Fourth cellulose conference, Syracuse, N. Y., 10/62, 17: 31806
**MARCONERO, R.,** Amplifier for neutron thermopile or thermocouple, 17: 32339 (RT/EL(63)3)
**MARDOC, V. R.,** PL condenser evaluation report, 17: 33303 (CEND-139)
**MARDUS, G.,** Mathematical exercises in nuclear engineering, 17: 32984
**MARGERUM, D. W.,** Multidentate ligand kinetics. III., 17: 32067
**MARGRAVE, J. L.,** Kinetics of reaction of F with Zr carbide and Zr diboride, 17: 32130
**MARKOVA, I. A.,** Rare earth alloys, 17: 32648
**MARLOTTE, Gary L.,** Hall current plasma accelerator, 17: 33205
**MARQUES, A.,** Multiple scattering measurements, 17: 32931
**MARSH, W. D.,** Utility system conditions favorable to installation of nuclear power, 17: 33348
**MARSHALL, Frank,** Improvements relating to nuclear reactors, 17: 33292
**MARTALOGU, N.,** Proton scattering by F-19 and Ar-40, 17: 33063
**MARTER, W. L.,** Radioiodine release incident, 17: 32284 (DPSPU-63-30-26B)
**MARTIN, D. W.,** Production of slow electrons and positive ions in He, Ne, Ar, $H_2$, $N_2$, $O_2$ and CO by helium ions, 17: 32731 (TID-19137)
**MARTIN, Troy C.,** Nuclear techniques in coal analysis, 17: 31985 (CONF-124-1)
**MARTINI, M.,** Fast transistorized pulse amplifier, 17: 32359
**MARTYNENKO, L. I.,** Rare earth separation by ion exchange, 17: 32202
**MARTYNOV, Yu. P.,** Heat release from high-activity solid substances, 17: 33407
**MARUYA, Kazuo,** Studies on Al–U alloys, 17: 32500
**MASH, D. R.,** Plasma-arc spraying of refractory metals, 17: 32545
**MASSART, D. L.,** Separation of rare earths, 17: 32197
**MATEESCU, N.,** Diffusion parameters of thermal neutrons in poisoned $H_2O$, 17: 32975
**MATHE, Gy.,** Elimination of superposed pulses in nuclear spectroscopy, 17: 32441
**MATHUR, Suresh C.,** Nuclear techniques in coal analysis, 17: 31985 (CONF-124-1)
**MATINYAN, S. G.,** Sign of mass difference of $K_1^0$ and $K_2^0$ mesons, 17: 32954
**MATINYAN, S. G.,** Stability of rotation of superfluid liquid, 17: 32808
**MATSON, L. K.,** Crystalline phases of rare-earth tellurides, selenides, and sulfides, 17: 32125
**MATSUI, Shigeo,** Electron beam trajectory tracing, 17: 32346
**MATTHEWS, Thomas A.,** Optical identification of 3C 48, 3C 196, and 3C 286, 17: 32847
**MAURER, W.,** Incorporation of [$H^3$] amino acids into the cell nucleus, 17: 31887
**MAXIA, V.,** Low γ and neutron fluxes chemical dosimetry, 17: 32460
**MAXWELL, R. L.,** Experimental stress analysis of nuclear reactor pressure vessel, 17: 33252
**MAY, T. H.,** Scattering of polarized neutrons by α particles, 17: 32932
**MAYES, Robert E.,** Nuclear propulsion systems for space flights, 17: 33336
**MAYS, C. W.,** Differential accumulation of I-131 from local fallout, 17: 31848
**MAZZOTTI, G.,** Present state of nuclear superheating, 17: 33336
**MC ALLISTER, R. G.,** Testing radium capsules for radon leakage, 17: 31879
**MC CARGO, M.,** Range of Xe-133 and Ar-41 ions in W, 17: 32747
**MC CAUGHEY, Owen J.,** Electrothermal arc-jet propulsion systems, 17: 32219
**MC CLURE, J. W.,** Structure of rare earth monosulfides, 17: 32082
**MC CONNELL, L. G.,** Early operating experience of NPD, 17: 33359
**MC CONNELL, L. G.,** Initial operating experience with the NPD reactor, 17: 33337
**MC DANIEL, E. W.,** Production of slow electrons and positive ions in He, Ne, Ar, $H_2$, $N_2$, $O_2$ and CO by helium ions, 17: 32713 (TID-19137)
**MC DIARMID, I. B.,** Satellite measurements in "Starfish" artificial radiation zone, 17: 32860
**MC ELROY, M. B.,** Fluorescence of solar ionizing radiation, 17: 32873
**MC ELROY, William N.,** Vapor pressure water boiler reactor, 17: 33297
**MC GEARY, Robert K.,** Fuel element for a reactor, 17: 32559
**MC GEE, H. L.,** Formation of thin polymer dielectric films by uv irradiation, 17: 32695
**MC ILROY, William,** Analytical performance of pinch plasma accelerator, 17: 33197
**MC KISSIC, E. M., Jr.,** Sensitivity of thorotrast-treated monkeys to staphylococcal enterotoxin, 17: 31918
**MC NALLY, J. R., Jr.,** Very high-energy injection into magnetic mirror, 17: 33160 (ORNL-3472(p.119-20))
**MC NEILL, K. G.,** Gamma-active fallout near Toronto, 1961–1962, 17: 32297
**MC NEILL, K. G.,** Photoproton telescope, 17: 32440
**MC NIFF, Edward J., Jr.,** Nuclear magnetic resonance in metal hexaborides, 17: 32083
**MC QUEEN, J. Donald,** Radioencephalographic scanning with As-74, 17: 31877
**MC QUISTAN, R. B.,** Infrared modulation by free carrier absorption, 17: 32729 (SCR-636)
**MC TAGGART, F. K.,** Proton-containing oxides of Ti, Zr, and Hf, 17: 32088
**MC WILLIAMS, P.,** Electronic processing and analysis of metabolic data, 17: 31815 (LADC-5627)
**MEASDAY, D. F.,** Reaction $C^{13}(p,p)C^{13m}$, 17: 33043
**MEASDAY, D. F.,** Reaction $C^{13}(p,\gamma)$ from 10 to 50 Mev, 17: 33044
**MEE, W. T.,** Nuclear Safety Handbook of Y-12 plant, 17: 32293 (Y-1272)
**MEERSON, G. A.,** Reduction of $ZrO_2$ by $CaC_2$ and $CaCN_2$, 17: 32059
**MEGILL, L. R.,** Electron energy distribution functions in ionosphere, 17: 32882
**MEHAFFEY, Joseph H.,** Parameters for background radiation measurements, 17: 32312
**MEIBOOM, S.,** Level indicator for liquid He, 17: 32365
**MEINHARDT, Dietrich,** Structure analysis for Fe-, W-, and Cr carbides, 17: 32057
**MEISEL, M. N.,** Regeneration of irradiated cells and type of energy metabolism, 17: 31890
**MEISSNER, H.,** Device for detection of solidified air on cold surfaces, 17: 32353
**MEISTER, H.,** Electronic measuring device for average amplitude, 17: 32354
**MEKHEDOV, V. N.,** Secondary D and T capture reactions, 17: 33075

**MEKHRJUSHEV, J. J.**, Properties of $Li_2O$–$Cs_2O$–$La_2O_3$–$SiO_2$ glasses, 17: 32096
**MENCUCCINI, C.**, Circuit to measure maximum energy of bremsstrahlung, 17: 32401 (LNF-63/17)
**MENON, K. K.**, Fallout of bomb-produced Ce isotopes, 17: 32298
**MENON, M. P.**, Fallout of bomb-produced Ce isotopes, 17: 32298
**MENY, L.**, Properties of $UO_2$–stainless steel fuel elements, 17: 33276
**MENZEL, Ronald G.**, Factors influencing biological availability of radionuclides for plants, 17: 31840
**MERCER, B. W.**, Inorganic ion exchange separation of Cs, 17: 33396 (HW-SA-2920)
**MERCER, T. T.**, Fission products released from irradiated U when heated in air. I., 17: 32287 (LF-9)
**MERCURI, R. A.**, Oxidation of $B_4C$ by air, $H_2O$, and air–$H_2O$ mixtures, 17: 32523
**MEREKOV, Yu. P.**, Emission of Li-8 in disintegration of Ag and Br by protons, 17: 33081
**MERGEN, Francois**, Prog. rpt. on radiation effects on forest trees, 6/61–5/62, 17: 31854 (TID-19067)
**MERKER, L. G.**, Hanford Pu fuel development laboratory, 17: 32537 (HW-SA-2904)
**MERRILL, J. A.**, Analysis of directional-correlation data, 17: 33031
**MERZBACHER, E.**, Energy levels in square well with hard core, 17: 33001 (CONF-128-1)
**MESTRE, E.**, Treatment and packaging of solid waste irradiated in pile, 17: 33410
**MESTVIRISHVILI, M. A.**, Majorization of Feynman diagrams for proving dispersion relations, 17: 32951
**MEYER, A. F.**, Preparation of thin converter foils, 17: 32769
**MEYER, Hans**, Radiation research and radiation treatment, 17: 31826
**MEYER, M. A.**, Properties of triggered multi-wire spark counters, 17: 32442
**MEYER, M. A.**, Track location in multi-wire spark counters, 17: 32443
**MICHAEL, W.**, Effect of x rays and scattered radiation of dental x-ray unit, 17: 32308
**MICHAELIS, W.**, Polarimeter for study of $\gamma$-$\gamma$ cascades, 17: 32400 (KFK-129)
**MICHAILOV, I. N.**, Use of projection in solving variational problems, 17: 32738
**MICHALEC, R.**, Beam of polarized neutrons, 17: 32977
**MICHAUDON, A.**, Moderated neutron beams from pulsed accelerators, 17: 32979
**MICHELS, Charles J.**, Performance of coaxial plasma gun with various propellants, 17: 33207
**MICKELSEN, William R.**, Radioisotope electrostatic propulsion system, 17: 33390
**MICU, M.**, Influence of residual interactions on nucleon–nucleus inelastic collision, 17: 33064
**MIGOTSKY, Eugene**, Skin effect in magnetofluiddynamic traveling-wave devices, 17: 32775
**MIKHAILOV, A. I.**, Atomic photoeffect at high energies, 17: 32810
**MIKHAILOVA, E. G.**, Distribution of S-35 among organs and tissues of the rat after injection of radiation-protective compounds, 17: 31943
**MIKHEEVA, V. I.**, Absorption of H by Ce–Mg alloys, 17: 32643
**MIKULSKI, J.**, Szilard-Chalmers effect in complex compounds. I., 17: 32168
**MILEIKOWSKY, Curt**, ASAE's work on heavy water reactors in Sweden, 17: 33350
**MILFORD, Frederick J.**, Hyperfine interaction in atomic Li, 17: 33102
**MILLER, A. D.**, Thermal decomposition of UN, 17: 32032 (CNLM-5066)
**MILLER, J. F.**, Crystalline phases of rare-earth tellurides, selenides, and sulfides, 17: 32125
**MILLER, Leon L.**, Fibrinogen turnover before and after x irradiation in the rat, 17: 31916
**MILLER, S. M.**, Radiation-induced vulcanization of hydrocarbon polymers. II, 17: 32167
**MILLS, F. E.**, Classical radiation damping in accelerators, 17: 33127
**MILLS, F. E.**, Proton linear accelerators for energies up to 300 Mev, 17: 33113 (CONF-125-3)
**MILLS, W. A.**, Iodine-131 in bovine thyroids following atmospheric fallout, 17: 32313
**MILTON, J. C. D.**, Kinetic energy and fine structure in spontaneous fission of Cf-252, 17: 32995 (CONF-46-44)
**MILTON, J. C. D.**, Prompt neutrons from individual fragments in fission of U-233 + n, 17: 33089
**MINARIK, E. V.**, Size of nuclei from $\pi^0$ photoproduction cross sections, 17: 33073
**MINER, F. J.**, Dicesium $PuCl_6$, proposed Pu standard, 17: 31991
**MINER, Roy Waldo**, Conference on ionizing radiation and the cell, New York City, 1954, 16: 31881
**MINZATU, I.**, Corrections of finite geometry and energy in analysis of fast neutron polarization, 17: 32939
**MIONE, Anthony J.**, Prog. rpt. on nuclear fuel, 6/63, 17: 32487 (NCSC-2981-4)
**MIRANDA, Ugo**, Plants for processing irradiated fuel elements, 17: 32201
**MIRONER, A.**, R-f heating of dense, moving plasma, 17: 33211
**MISHCHENKO, L. G.**, Nuclear particle spectrum at 3260 m altitude, 17: 32892
**MISRA, S. K.**, System uranyl acetate–benzilic acid–water, 17: 32085
**MITAMURA, Noritsugu**, Studies on Al–U alloys, 17: 32500
**MITCHELL, A.**, Measuring energy of $\alpha$ beams from 5 to 30 Mev, 17: 32772
**MITCHELL, O. M. Mracek**, Photoproton telescope, 17: 32440
**MITLER, Henri E.**, Helium-3 in planetesimals, 17: 32866
**MIYAKE, Kiyoshi**, Formation of $Cs_3Sb$. II., 17: 32624
**MIYAKE, Kiyoshi**, Formation of $Cs_3Sb$. III., 17: 32625
**MIYANAGA, Ichiro**, Sensitivities of Fuji badge film to $\beta$ rays, 17: 32414
**MIYAO, Noboru**, Strontium-90 in bone of animals in Japan, 17: 32300
**MIZUKAWA, Kiyoshi**, Effect of Zr on grain size in Fe and steel, 17: 32627
**MKRTCHYAN, S. M.**, Reciprocal ternary system formed by bromides and nitrates of Na and Ba, 17: 32112
**MLADENOVIC, M.**, Preparation of thin $\beta$-ray sources and U convertors, 17: 32770
**MODEL, I. Sh.**, Production of shock waves in electric discharges, 17: 32801
**MOECK, E. O.**, Steam/water mixtures flowing in heated annulus, 17: 32260
**MOELLER, H. B.**, Reflecting multi-channel collimators, 17: 32982
**MOHINDRA, V. K.**, Gamma-active fallout near Toronto, 1961–1962, 17: 32297
**MOHLING, Franz**, Second virial coefficient for He, 17: 32773
**MOLITOR, Jerome H.**, Electric thrust devices for spacecraft propulsion, 17: 32222
**MONASTERIO, Gabriele**, Prog. rpt. on radiocardiographic techniques, annual, 7/20/63, 17: 31819 (TID-19173)
**MONTBRIAND, L. E.**, Auroral patches showing strong H lines, 17: 32861
**MONTEYNE-POULAERT, G.**, Ages of pegmatite and vein minerals from Rwanda and Burundi, 17: 32268
**MONTGOMERY, David**, Nonlinear Landau damping of oscillations in bounded plasma, 17: 33169
**MOONEY, L. G.**, Fast-neutron attenuation through nine-inch polyethylene slab, 17: 32988
**MOORADIAN, A. J.**, Development of reactor fuels in Canada, 17: 33258
**MOORE, A. M.**, Ultraviolet irradiation of pyrimidine derivatives. IV., 17: 32159
**MOORE, Booker T.**, Design of isotope storage area, 17: 32296
**MOORE, R. A.**, Note on angular distribution analysis, 17: 33033
**MOORE, W.**, Iodine-131 in bovine thyroids following atmospheric fallout, 17: 32313
**MOORE, William H., Jr.**, *In vivo* activation in mice of C-12, N-14, and O-16, 17: 31851 (BNL-6989)
**MORAVEK, P. H.**, Unitary operators in quantum field theory, 17: 32717 (NP-12996(p.29-35))
**MORGAN, C. S.**, Dislocation movement in sintering of $CaF_2$, 17: 32037 (CONF-50-14)
**MORGAN, C. S.**, Material transport during sintering of fluorite structure materials, 17: 32535 (CONF-50-15)
**MORGAN, Ira L.**, Nuclear techniques in coal analysis, 17: 31985 (CONF-124-1)
**MORGAN, J. E.**, Problems peculiar to electron therapy, 17: 31824
**MORLEY, John R.**, Hollow cathode discharge, 17: 32822
**MORRIS, Melvin L.**, Gas phase chromatography of metal chelates, 17: 32068
**MORRISON, G. C.**, Lifetimes of levels in Ne-21, 17: 33098
**MORTON, P.**, Betatron oscillation frequencies in spiral sector FFAG accelerator, 17: 33111 (CONF-125-1)
**MOSETTI, Ferruccio**, Microbarographic recordings of nuclear explosions,

17: 32267
**MOSHIER, Ross W.,** Gas phase chromatography of metal chelates, 17: 32068
**MOSS, William T.,** Radiation effects on small blood vessels, 17: 31874
**MOTTEL, W. J.,** Ion exchange unit for radiochemical separation, 17: 32198
**MOTZ, H.,** Magnetization of Gd near Curie point, 17: 32646
**MUELLER, Guenther,** Decay of Tm-168, 17: 33008 (ZFK-PHA-8)
**MUELLER, J.,** Use of radioactive isotopes in surgery, 17: 31828
**MUELLER, K.,** Radiation exposure of man by television sets and luminous dials, 17: 32309
**MUELLER, N.,** Sintering of $UO_2$, 17: 32544
**MUELLER, R. W.,** Electron injection into a microtron, 17: 33129
**MUENZE, R.,** Uranium multiple fission. V., 17: 33030
**MUIR, C. W. A.,** Precipitation of double fluoride salts of U, 17: 32187
**MUNDSCHENK, H.,** Separation of short-lived nuclides by $\beta$ recoil, 17: 32173
**MUNSON, M. S. B.,** Ion source pressures in mass spectrometers, 17: 32387
**MUR, V. D.,** Matrix structure of $\pi$-$\gamma$, N-$\gamma$, and $\gamma$-$\gamma$ amplitudes, 17: 32962
**MURAKAMI, Yotaro,** Heat treatment of Zr-rich alloys, 17: 32626
**MURDOCH, R.,** Chemical factors influencing the thermal oxidation of nuclear graphite, 17: 32128
**MURRAY, G.,** Absolute energy of Hg-198 412-kev $\gamma$ radiation, 17: 33050
**MURRAY, G. T.,** Precipitation of He during annealing of Al–Li alloy, 17: 32603
**MURRAY, P.,** Symposium on nuclear ceramics, 17: 33263
**MURTHY, P. V. Ramana,** Total absorption spectrometer for Bev range, 17: 32439
**MURZIN, V. S.,** Nuclear particle spectrum at 3260 m altitude, 17: 32892
**MUTO, Haruo,** Determination of O by 14-Mev neutron activation analysis, 17: 32022
**MUZDEKA, S. D.,** G-M counters as switching elements, 17: 32425
**MYERS, H. P.,** Paramagnetism of Mn dissolved in Cu–Al and Cu–Ge alloys, 17: 32561 (AE-111)

# N

**NAGATA, Takesi,** Geomagnetically conjugate relationships of giant pulsations, Antarctica and Iceland, 17: 32867
**NAHORNIAK, V.,** Diffusion parameters of thermal neutrons in poisoned $H_2O$, 17: 32975
**NAITO, Yoshihide,** Glass for radiation sterilization of medicines, 17: 32675
**NAKAMURA, Masanori,** Radiation effects on adrenal glands of rats and mice, 17: 31910
**NAKAMURA, Michiyuki,** Multiparameter pulse-height recording system, 17: 32343 (UCRL-10874)
**NAKASIMA, Ryuzo,** Angular distributions of $\alpha$ particles from $Li^6$-induced reactions, 17: 33088
**NAKATANI, Hiroshi,** Effect of particle size of sintered Be powder, 17: 32588
**NAKATANI, S.,** Properties of natural radioactivity in atmosphere, 17: 32280
**NAMBA, S.,** Formation of $UC_{1-x}$ $O_x$ and $UC_{1-x}$ $N_x$, 17: 32132
**NAMYSLOWSKI, Jozef,** Symmetrical form of Dirac matrices in general relativity, 17: 32736
**NAOAKI, Takahashi,** Effect of metal addition upon 2S, 52S, and 61S Al, 17: 32608
**NASH, A. E.,** Half-lives of Cs-137 and Co-60, 17: 32719 (NP-12996(p.38-42))
**NAUMANN, D.,** Reprocessing of irradiated fuels, 17: 32199
**NAUMKIN, O. P.,** Magnetic properties of Sc single crystals, 17: 32640
**NAUMKIN, O. P.,** Rare earth alloys, 17: 32648
Navascues Navascues, Fermin
*see Navascues, Fermin Navascues*
**NEAMU, I.,** Proton scattering by F-19 and Ar-40, 17: 33063
**NEBEL, D.,** Polarographic studies of Pu in aqueous solution, 17: 32139
**NEFEDOV, O. M.,** Thermal and radiation stability of aromatic compounds, 17: 32156
**NEIDING, A. B.,** Fluorides of Xe and Rn, 17: 32051 (AEC-tr-5920)
**NEKRASOVA, T. N.,** Lithium silicate glasses containing oxides of Y, 17: 32094
**NEKROT, A. A.,** Angular collective variables for computing statistical sum of mixed ionic-dipole system. I., 17: 32795
**NELSON, D. C.,** Absolute calibration of gas chromatographic apparatus, 17: 32384
**NELSON, Eric L.,** Immunologic unresponsiveness in adult, x-irradiated rabbits, 17: 31914
**NELSON, J. L.,** Inorganic ion exchange separation of Cs, 17: 33396 (HW-SA-2920)
**NELSON, R. C.,** Failures of $UO_2$ swaged fuel rod, 17: 32664 (GEAP-4197)
**NELSON, S. G.,** Stability of molten U and refractory carbides, 17: 32036 (CONF-40-2)
**NELSON, Wilfred H.,** Structure of polyanions of transition metals in aqueous solution, 17: 32123
**NEMETS, O. F.,** Elastic scattering of deuterons on Cr and Zn isotopes, 17: 33071
**NEMETS, O. F.,** Study of nuclear reactions on the cyclotron, 17: 33036
**NEMIROVSKII, P. E.,** Optical model for cross sections of radiative capture, 17: 33048
**NESMEYANOV, An. N.,** Vapor pressure of Ca and Sr, 17: 32050 (AEC-tr-5911)
**NESTEROV, S. V.,** Dose field created by $\gamma$ emitter at border of two media, 17: 32299
**NEUMANN, H.,** Irradiation facilities in Ispra I reactor, 17: 33365 (EUR-374.e)
**NEUMANN, O.,** Manufacture of $UO_2$ fuel elements, 17: 33247
**NEURINGER, Joseph L.,** Skin effect in magnetofluiddynamic traveling-wave devices, 17: 32775
**NEWKIRK, J. B.,** Metallographic etching by monoenergetic ion bombardment, 17: 32505
**NICOLAE, M.,** Preparation of nuclear emulsion with fine granulation, 17: 32407
**NIELSEN, H.,** Six-meter focal length Ebert-type infrared spectrograph. I and II, 17: 32341 (TID-19175)
**NIFENECKER, H.,** Fission cross section of U-233, 17: 33029
**NIKOLAEV, F. A.,** Reaction $C^{13}(p,p)C^{13m}$, 17: 33043
**NIKOLAEV, F. A.,** Reaction $C^{13}(p,\gamma)$ from 10 to 50 Mev, 17: 33044
**NILAN, R. A.,** Analysis of radiation-induced genetic damage in seeds, 17: 31869
**NILAN, R. A.,** Production of radiation-induced genetic effects in plants, 17: 31951
**NILSSON, Lars,** Burnout conditions for flow of boiling water in vertical round ducts. II., 17: 32243 (AE-114)
**NISEL'SON, L. A.,** Reactions of Sc chlorides with ethylenediamine, 17: 32147
**NOAKES, Michael Lesney,** Improvements in fuel elements, 17: 33287
**NOERDLINGER, Peter D.,** Plasma oscillations in electric field, 17: 33179
**NOLDER, Richard L.,** Substructure of plastically deformed nickel, 17: 32576 (UCRL-10778)
**NOLTE, Lothar,** Lithium-glass scintillators for detection of neutrons, 17: 32405 (ZFK-RN-19)
**NOONEY, Grove C.,** UNFOLD—program for analyzing linear systems, 17: 32476 (UCRL-10927)
**NORREYS, J. J.,** Physical properties of UC, 17: 32636
**NORTHUP, T. E.,** High-density slag concrete, 17: 33222 (ORNL-3473)
**NOUVELLE, Usine,** Niobium and Ta, 17: 32508
**NOVAK, V. P.,** Titration of Fe(2+) by Ce(IV) sulfate, 17: 32024
**NOVIKOV, G. I.,** Evaporation of rare earth tetrachlorides, 17: 32118
**NOVIKOVA, M. N.,** Transformation of hemopoietic cells in irradiated dogs, 17: 31969
**NOVOZHILOV, Y. V.,** Theory of elementary particle symmetries, 17: 32943
**NOWER, T. M.,** Reaction $Al^{27}(p,\alpha_0)Mg^{24}$ at 1 to 2.5 Mev, 17: 33045
**NOWOTNY, H.,** Niobium–Ta alloys for impregnation, 17: 32495
**NUZHDIN, N. I.,** Chromosome aberrations as function of irradiation intensity, 17: 31902
**NYHOLM, R. S.,** Chemistry of Re and Tc, 17: 32137
**NYMAN, Ci.,** Effect of x rays and botulinum toxin on survival of mice, 17: 31901

# O

**OBERHAUSEN, Erich,** Measurement of radionuclides in people, 17: 32301
**OBERLY, W. N.,** Utility system conditions favorable to installation of nuclear power, 17: 33348
**O'BRIEN, J. P.,** Level indicator for liquid He, 17: 32365
**OCCHIPINTI, E. S.,** Calcination of waste in molten S, 17: 33402
**O'CONNELL, R. F.,** K-shell internal conversion coefficients at threshold,

17: 33047
**O'DELL, C. R.**, Evolution of central stars of planetary nebulae, 17: 32849
**OEHME, Reinhard**, Vector mesons as Regge poles in perturbation theory, 17: 32902 (EFINS-63-35)
**OGANDZHANYAN, E. E.**, Blood formation and viability in irradiated mice, 17: 31941
**OGAWA, Kazuyuki**, Determination of O by 14-Mev neutron activation analysis, 17: 32022
**OGDEN, Horace R.**, Properties of F-48 Nb alloy, 17: 32567 (BMI-X-249)
**O'GRADY, J. J.**, Electrode thermionic converter, 17: 32702 (ASD-TDR-63-442)
**O'HALLORAN, G. J.**, Plasma analysis with time-of-flight mass spectrometer, 17: 33213
**OHANIAN, M. J.**, Water spectra and energy exchange kernels, 17: 32970 (CONF-11-5)
**OJEMANN, R. G.**, Separation of Sc-49 from Ca target, 17: 32164
**OKADA, Toshio**, Radiation copolymerization to cellulose. II., 17: 32676
**OKANO, M.**, Solid-state logarithmic amplifier, 17: 32349
**O'KELLEY, G. Davis**, Nuclear chemistry. II., 17: 32815
**OLESOV, Yu. G.**, Reduction of $ZrO_2$ by $CaC_2$ and $CaCN_2$, 17: 32059
**OLIPHANT, Thomas A., Jr.**, Heat flow in liquid He II, 17: 32740
**OMAROV, T. G.**, Isotopic effect in volumes N isotope unit cells, 17: 32106
**ONCESCU, M.**, Beta radioactivity of zooplankton of Black Sea, 17: 31843
**O'NEILL, Gerard K.**, Storage rings, 17: 33140
**ONO, Kenichi**, CP invariance and concept of antiparticles, 17: 32940
**O'RILEY, L. J.**, Winter rail-lubricant study, 17: 32326
**ORLOV, Yu. V.**, Direct nuclear reactions in initial and final states, 17: 33085
**ORR, W. L.**, Prototype nuclear-fueled thermionic converter test, 17: 32836
**ORRALL, Frank Q.**, Macroscopic inhomogeneities in solar atmosphere. IV., 17: 32856
**ORRELL, Brendon**, Improvements in reactor fuel elements, 17: 33284
**OSBORNE, Darrell W.**, Heat capacity of Dy metal, 17: 32654
**OSHCHERIN, B. N.**, Calculation of boiling point, 17: 32592
**OSIPOV, A. I.**, Distribution of energy according to molecular freedom in disturbed Maxwellian distribution, 17: 32811
**OSTERLE, J. F.**, Thermoelectric and thermomagnetic generators, 17: 32831
**OSTERRIETH, Paul M.**, Induction by x-rays of the destruction of DNA of *Escherichia freundii*. II., 17: 31899
**OSTROVSKII, Yu. A.**, Data on pulse shape induced in drill holes, 17: 32271
**OTT, Karl**, Doppler coefficients of fast reactors, 17: 33242 (KFK-153)
**OVERTON, W. C., Jr.**, Phenomena along the hcp-bcc transition line of He-3 and He-4, 17: 32776
**OWEN, Charles A., Jr.**, Radiochromium-labeled lymphocytes in the rat, 17: 31917
**OWEN, L. W.**, Deposition of Zr coatings, 17: 32507
**OWEN, W. S.**, Substructure and mechanical properties of refractory metals, 17: 32565 (ASD-TR-61-181(Pt.III))
**OZIRANER, S. N.**, Solidification of radioactive waste solutions, 17: 33406
**OZISIK, M. N.**, Fission-product transport and deposition from gas streams, 17: 33243 (ORNL-3379)

# P

**PADEKHNOVA, E. M.**, Properties of Mg–Th–Mn system, 17: 32595
**PAGNAMENTA, Antonio**, Regularity of the *T* matrix, 17: 32926
**PAHLER, Robert E.**, Objectives and plans for AEC's civilian power GCR program, 17: 33304 (CONF-39-33)
**PAIC, M.**, Yields of D-D neutrons from different targets, 17: 32768
**PAIDASSI, J.**, Oxidation of UC in carbonic anhydride, 17: 32127
**PAILLON, M.**, Reactivity effects due to variations in nuclear parameters, 17: 33307 (EUR-281.e)
**PALLADIEV, N. M.**, Integral absorbed dose in Ra therapy, 17: 31906
**PALMER, R. B.**, Flying spot film measuring machine employing crossed glass fibers, 17: 32332 (BNL-6878)
**PALOMARES-DELGADO, F.**, Determination of U in organic solvents, 17: 32000
**PALOMARES-DELGADO, F.**, Determination of U extracted with methyl isobutyl ketone–TBP, 17: 32001
Palomino, J. Vera
*see Vera Palomino, J.*
**PAMPUCH, R.**, Sintering of single- and two-component crystalline powder, 17: 32542 (UCRL-Trans-953(L))
**PANCHENKO, A. M.**, Gamma field of beam from point source of Cs-137 or Co-60, 17: 32923
**PANDE, C. S.**, System uranyl acetate–benzilic acid–water, 17: 32085
**PANDYA, S. P.**, Effective nuclear interactions in O isotopes, 17: 33100
**PANETH, F.**, Quantitative measurement of small amounts of He, 17: 31987 (AAEC/Trans-14)
**PANFILOVA, N. P.**, Properties of alkali silicate glasses, 17: 32095
**PANNETIER, Guy**, Thermal decomposition of $La_2(SO_4)_3 \cdot 9H_2O$. I., 17: 32062
**PANTUEV, V. S.**, Measurement of Panofsky ratio by coincidences, 17: 32947
**PAPP, Elemer**, Extraction of elements from bauxites, 17: 32065
**PAREISHVILI, E. A.**, Blood formation and viability in irradiated mice, 17: 31941
**PARFENOV, A. I.**, Lithium silicate glasses containing oxides of Y, 17: 32094
**PARFENOV, A. I.**, Properties of alkali silicate glasses, 17: 32095
**PARFENOV, A. I.**, Properties of $Li_2O–Cs_2O–La_2O_3–SiO_2$ glasses, 17: 32096
**PARFENOV, A. I.**, Properties of polycomponent Li silicate glasses, 17: 32098
**PARGAMANIK, L. E.**, Energy levels of single-electron atoms and ions in plasma, 17: 33191
**PARIKH, P.**, Measurement of nucleus polarization in weak magnetic fields, 17: 32390
**PARIS, Giuseppe**, Welding of reactor for electrothermal nuclear plant, 17: 33260
**PARKER, E. N.**, Solar-flare phenomenon and magnetic field annihilation and reconnection, 17: 32859
**PARKER, E. N.**, Theory of turbulent hydromagnetic fields, 17: 32854
**PARKER, J. B.**, Interpretation of recoil proton spectra, 17: 32420
**PARKER, P. D.**, Direct-capture model for $He^3(\alpha,\gamma)Be^7$ and $T(\alpha,\gamma)Li^7$ reactions, 17: 33104
**PARKER, P. D.**, Reaction $He^3(\alpha,\gamma)Be^7$, 17: 33103
**PARKER, R. G.**, Dosage to important sites in radiation therapy, 17: 31872
**PARKER, Roy A.**, Computer activities of Spectroscopy Group at LSU, 17: 32481
**PARKHOMENKO, I. M.**, Effect of protective substances on γ-irradiated monkey heart, 17: 31944
**PARLETT, Beresford**, Development and use of methods of LR type, 17: 33226 (NYO-10429)
**PARZEN, G.**, Betatron oscillation frequencies in spiral sector FFAG accelerator, 17: 33111 (CONF-125-1)
**PARZEN, G.**, Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)
**PASCHKE, Raymond F.**, Crosslinking of fatty polyamides with radiation, 17: 32181
**PASECHNIK, M. V.**, Neutron physics of intermediate energies, 17: 32990
**PASECHNIK, M. V.**, Study of nuclear reactions on the cyclotron, 17: 33036
**PASHOS, T. J.**, Failures of $UO_2$ swaged fuel rod, 17: 32664 (GEAP-4197)
**PASOTTI, G.**, Superconducting magnets, 17: 32712 (LNF-63/26)
**PASSELL, L.**, Reflecting multi-channel collimators, 17: 32982
**PASTEELS, P.**, Absolute age of uraniferous minerals of Katanga and Northern Rhodesia, 17: 32265
**PATASHINSKII, A. Z.**, Regge poles in quasiclassical potential well, 17: 32956
**PATRICK, J.**, Stopping power of atoms having many electrons, 17: 33223 (UCRL-Trans-972)
**PATTERSON, C. C.**, Lead in Atlantic and Mediterranean waters, 17: 32274
**PATWARDHAN, P. K.**, Address logic of kicksorter employing ADC, 17: 32437
**PAULL, D. L.**, Absolute calibration of gas chromatographic apparatus, 17: 32384
**PAVLINCHUK, V. A.**, Fission threshold from (d,pf) and (γ,f) reactions, 17: 33082
**PAWLICKI, S.**, Optimum reactor shielding, 17: 33281
**PAYA, D.**, Fission cross section of U-233, 17: 33029

**PEACOCK, Charles L., Jr.,** Computer activities of Spectroscopy Group at LSU, 17: 32481
**PEACOCKE, A. R.,** Action of $\gamma$ rays on Na deoxyribonucleate in solution. IV., 17: 31912
**PEFHANY, J.,** Measurement of metal creep under reactor fast neutron irradiation, 17: 32697
**PEHLKE, Robert D.,** Activity coefficients in binary liquid metallic solutions, 17: 32633
**PEISER, H. S.,** Symmetry splitting of equivalent sites in oxide crystals, 17: 32607
**PELATI, L.,** Beta radioactivity of plankton in Adriatic and Ligurian seas, 17: 31845
**PELLICCIONI, M.,** Response to fast neutrons of $BF_3$ counter, 17: 32432
**PENDLETON, R. C.,** Differential accumulation of I-131 from local fallout, 17: 31848
**PENFOLD, A. S.,** Single-phase induction plasma accelerator, 17: 33192
**PENG, Hong-en,** Low energy $\pi$-N and $\pi$-$\pi$ scattering, 17: 32949
**PENG, Hwan-wu,** Life-time correlation experiments, 17: 33069
**PENNEMAN, R. A.,** Preparation of ammonium U(IV) and ammonium Pu(IV) fluorides, 17: 32072
**PENNINGTON, R. T.,** Prog. rpt. on EVESR superheat fuel, 12/62–2/63, 17: 33309 (GEAP-4200)
**PERCUS, Jerome K.,** Calculating ground-state properties of many-particle systems, 17: 33227 (NYO-10431)
**PEREY, F. G. J.,** Optical-model neutron transmission coefficients, 17: 32968 (BNL-765)
**PEREZ Y JORBA, J.,** Recoil protons from e-p scattering at 950 Mev, 17: 32905 (LAL-1072)
**PERFILOV, N. A.,** Ternary fission of U-235 with 14-Mev neutrons, 17: 33020
**PERFILOV, N. A.,** Triple fission of Pu, 17: 33079
**PERKIN, J. L.,** Reaction $H^3(t,n)He^4$ as neutron source, 17: 33035
**PERL, M. L.,** Elastic scattering of negative pions by protons, 17: 32906 (NP-12990)
**PERLOW, G. J.,** Mössbauer effect in compounds of Xe-129, 17: 32089
**PERLOW, M. R.,** Mössbauer effect in compounds of Xe-129, 17: 32089
**PERONA, G.,** Process for producing little $UO_2$ sintered spheres, 17: 32556
**PERSSON, A.,** Hindered E2 ground state transition in Po-207, 17: 33039
**PERSSON, Per,** Burnout conditions for flow of boiling water in vertical round ducts, 17: 32242 (AE-113)
**PERSSON, Per,** Burnout conditions for flow of boiling water in vertical round ducts. II., 17: 32243 (AE-114)
**PESHEKHONOVA, N. V.,** Properties of Li silicate glasses, 17: 32097
**PESSON, P.,** Radiation doses capable of arresting insect infestation of cereals and flour, 17: 32323
**PETERSON, R. M.,** Stress analysis of HNPF loading-face shield, 17: 33251
**PETRASCU, E.,** Choice of parameters of linear electron accelerator, 17: 33135
**PETREE, Marcella C.,** Luminescence in neutron-irradiated GaAs diodes, 17: 32672
**PETREMENT, J.,** Determination of U extracted with methyl isobutyl ketone–TBP, 17: 32001
**PETREMENT-EGUILUZ, J.,** Determination of U in organic solvents, 17: 32000
**PETROV, A. D.,** Thermal and radiation stability of aromatic compounds, 17: 32156
**PETROV, V. A.,** Integral absorbed dose in Ra therapy, 17: 31906
**PETRZHAK, K. A.,** Characteristics of ternary fission in U and Pu, 17: 33019
**PETVIASHVILI, V. I.,** Anomalous diffusion of plasma with oscillations, 17: 33190
**PFEFFER, G.,** Light impulse generators in the nanosecond region, 17: 32212
**PFEIFER, P. E.,** Does ring wear predict cylinder wear? Radiotracer data, 17: 32226
**PFOHL, H.,** Shielding calculations—pot calcination demonstration, 17: 33397 (ORNL-TM-595)
**PHILIBERT, Jean,** Kirkendall effect and chemical and intrinsic diffusion coefficients in U–Mo, 17: 32578 (AEC-tr-5932)
**PHILIBERT, Jean,** Uranium–Zr diffusion in $\gamma$ phase, 17: 32577 (AEC-tr-5931)
**PHILLIPS, John D.,** Digital computer program for thermodynamic properties of $D_2O$, 17: 32038 (CVNA-129)
**PHILLIPS, K.,** Cloud chamber study of electron avalanche growth, 17: 32786
**PICCIOTTO, E.,** Bibliography of absolute dating measurements in Antarctic, 17: 32266
**PICKLER, D. A.,** Safety problems of nuclear reactors in space, 17: 33380
**PIDDINGTON, J. H.,** Ionospheric drifts and E-region irregularities, 17: 32872
**PIDGEON, L. M.,** Production of reactive metals, 17: 32504
**PIERCE, C. B.,** Defects introduced in neutron-irradiated Esaki diodes, 17: 32680
**PIETRA, R.,** Preparation of colloidal chromic phosphate, 17: 32075
**PIETRI, Charles E.,** Purification of Pu sulfate tetrahydrate, 17: 32055
**PINCHERA, G. C.,** Heat transfer by organic liquids, 17: 32254
**PINCHUK, L. B.,** Sodium lactate in radiation sickness, 17: 31964 (JPRS-20469)
**PINNINGTON, E. H.,** Neutral spectrum of Lu, 17: 32750
**PINNINGTON, E. H.,** Zeeman effect data for singly ionized Lu, 17: 32751
**PINTO, R. I.,** Early radiation effect by changes in lymphocytes, 17: 31952
**PIPER, D. E.,** Stress corrosion of Al–Zn–Mg alloys, 17: 32530
**PIVOVAROV, V. G.,** Contribution of strong interactions to photon Green function, 17: 32955
**PLAKSIN, I. N.,** Selective determination of elements on basis of $(\alpha,n)$ and $(\alpha,p\gamma)$ reactions, 17: 32015
**PLASTINO, A.,** Beta spectroscopy with solid-state detectors, 17: 32421
**PLATT, Allison M.,** Radioactive waste fractionization and packaging, 17: 33395 (HW-SA-2786)
**PLATZMAN, P. M.,** Transmission of EM waves through plasma slabs, 17: 33218
**PLETZ, R. H.,** Nuclear Safety Handbook of Y-12 plant, 17: 32293 (Y-1272)
**POCIUS, V. (V. Yu. Potsiyus),** Studies of $\alpha$ radioactivity in atmosphere, 17: 32888
**PODA, G. A.,** Monitoring, decontamination, and bio-assay of Pu-contaminated injury, 17: 31962 (DPSPU-63-30-5)
**PODESTI, M.,** Fabrication of compacted $UO_2$ pellets, 17: 32555
**POKROVSKII, V. L.,** Regge poles in quasiclassical potential well, 17: 32956
**POLIKARPOV, V. I.,** Deposition of Cs and Rb from $CO_2$ onto materials, 17: 32061
**POLOZOVA, I. P.,** Lithium silicate glasses containing oxides of Y, 17: 32094
**POLUBOYARINOVA, Z. I.,** Renal function of dogs affected with radiation, 17: 31968
**POLYACHENOK, O. G.,** Evaporation of rare earth tetrachlorides, 17: 32118
**POMELAS, E.,** Two-dimensional registration in coincidence, 17: 32423
**POMERANTSEVA, M. D.,** Effects of fast neutrons and x radiation on gonads of mice, 17: 31891
**POMERANTZ, M. A.,** Scintillator meson telescope, 17: 32419
**PONDER, B. W.,** Gas phase chromatography of metal chelates, 17: 32068
**POOLE, L. K.,** Development of Ni alloy surfacing techniques, 17: 32509
**POP, Ioan,** Operation of diffusion-condensation chamber, 17: 32450
**POP, Iuliu,** Magnetic properties of Sc single crystals, 17: 32640
**POP, R.,** Preparation of nuclear emulsion with fine granulation, 17: 32407
**POPOLI, Giovanni,** Welding of reactor for electrothermal nuclear plant, 17: 33260
**POPOV, V. A.,** Effects of magnetic fields on electroconductivity, 17: 32814
**POPOVA, T. G.,** Therapeutic action of highly polymerized DNA in radiation sickness, 17: 31973
**PORNEUF, A.,** Fabrication of dense UC bars, 17: 32551
**PORNEUF, A.,** Sintering of $UO_2$ in a continuous furnace, 17: 32550
**PORTER, C. E.,** Random matrix diagonalization, 17: 32480
**PORTNOI, K. I.,** Polymorphism of rare earth oxides, 17: 32058
**POSPELOV, Yu. A.,** Galvanomagnetic effects and electron spectrum of graphite, 17: 32641
**POST, Richard F.,** Magnetic end closures for plasma devices, 17: 33221
**POST, Richard F.,** Reducing impurity resistivity of Na, 17: 32843
**POTEMANS, M.,** Operational results of BR3, 17: 33341
**POTTER, John,** Quasi-free electron scattering in the impulse approximation, 17: 33037

**POULIS, N. J.**, Dynamic polarization of protons in polystyrene, 17: 32779
**POUND, R. V.**, Magnetic resonance studies of unpaired atoms in solid $D_2$, 17: 32042 (TID-19123)
**POVH, B.**, Low-lying states in Al-26, 17: 33057
**POWERS, R. M.**, Prog. rpt. on direct conversion of $UF_4$ to UC, final, 7/61–6/62, 17: 32182 (GTR-17)
**PRACHT, D. W.**, Application of NMR to transition metals, 17: 32569 (CONF-54-1)
**PRCKOSHKIN, Yu. D.**, Measurement of Panofsky ratio by coincidences, 17: 32947
**PREDOVSKII, A. A.**, Deposits of U in coals, 17: 32277
**PREISS, Ivor L.**, Excitation functions for Li-6 induced reactions on Au-197, 17: 33038
**PRICE, P. B.**, Charged particle tracks in glass, 17: 32696
**PRIDGEON, J. W.**, Stress corrosion cracking in U–Mo alloys, 17: 32518 (Y-1417)
**PRIGOGINE, I.**, Correlations in a nonisothermal plasma, 17: 33182
**PRILEZHAEV, D. S.**, Four-level optical generator, 17: 32804
**PRINGLE, J. P. S.**, Beta spectroscopy for study of anodic oxidation, 17: 32532
**PRISELKOV, Yu. A.**, Vapor pressure of Ca and Sr, 17: 32050 (AEC-tr-5911)
**PROCTOR, J. F.**, Ion exchange unit for radiochemical separation, 17: 32198
**PROIMOS, Basil S.**, Precise teletherapy with Co-60 units, 17: 31823
**PROKHONCHUKOV, A. A.**, Effect of P-32 on mineral and protein metabolism, 17: 31925
**PROSSER, Reese T.**, Relativistic potential scattering, 17: 32928
**PROTASOVA, T. N.**, Enzyme system oxidizing tyrosine in irradiated animals, 17: 31884
**PROTTI, A. M.**, Rate of grain growth of $UO_2$, 17: 32600
**PRYALOCHNIKOV, V. I.**, Reduction of $ZrO_2$ by $CaC_2$ and $CaCN_2$, 17: 32059
**PUCHEROV, N. N.**, Study of nuclear reactions on the cyclotron, 17: 33036
**PUSHKAR', N. S.**, Treatment of acute radiation sickness by bone marrow, 17: 31963 (JPRS-20282(p.17-26))
**PUSHKINA, G. Yu.**, Preparation and properties of Sc nitrates, 17: 32172
**PUSHKINA, G. Yu.**, Solubility of $Sc(NO_3)_3$ and $ScOH(NO_3)_2$, 17: 32115
**PYATIGORSKII, G. M.**, Energy levels of single-electron atoms and ions in plasma, 17: 33191

## Q

Quaranta, A. Alberigi
*see Alberigi Quaranta, A.*
**QUASE, Harold G.**, Underwater storage system, 17: 32229
**QUINN, E. P.**, Prog. rpt. on transition boiling heat transfer, 4–6/63, 17: 32247 (GEAP-4307)
**QUINTILIANI, M.**, Factors affecting *in vitro* inactivation of aldolase by x-rays, 17: 31961

## R

**RAABE, E. W.**, Separation of Li values, 17: 32205
**RABOTNOV, N. S.**, Fission threshold from (d,pf) and (γ,f) reactions, 17: 33082
**RADCLIFFE, J. M.**, Mössbauer effect for an impurity nucleus. I., 17: 33096
**RADO, P.**, Slip cast crucibles of $CaF_2$ and their use in smelting of U, 17: 32543
**RAE, E. R.**, Nanosecond neutron time-of-flight system, 17: 33032
**RAGGENBASS, A.**, Storing highly radioactive waste, 17: 33401
**RAGSDALE, Robert G.**, Outlook for gas-core nuclear rockets, 17: 33383
**RAI, Kanti**, Lymphocyte production measured by extracorporeal irradiation, 17: 31852 (BNL-7137)
**RAIFORD, Maurice T.**, Measurement of Faraday effect in magnetoplasma, 17: 33198
**RAIKHBAUM, Yu. D.**, Spectral analysis of Ta and Nb, 17: 32025
**RAJE, Surendra A.**, Fortran program for unit cell nuclear design calculations, 17: 33238 (CVNA-146(Vols.I & II))
**RAMAIYA, L. K.**, Effects of fast neutrons and x radiation on gonads of mice, 17: 31891
**RAMALINGAM, K. V.**, Radiation-induced graft polymerization of styrene in wood, 17: 31807
**RAMINS, Peter**, Performance of coaxial plasma gun with various propellants, 17: 33207
**RAMSEY, Bob N.**, Rare earth metal–metal halide systems. VI., 17: 32074
**RANGARAJAN, C.**, Active particles in fallout from weapon tests, 17: 32283 (AEET/AM/34)
**RANKIN, M. O.**, Protective clothing monitoring system, 17: 32286 (HW-76351)
**RANKIN, Mozelle**, Very high-energy injection into magnetic mirror, 17: 33160 (ORNL-3472(p.119-20))
**RAO, K. Narahari**, $\nu_3$ and $\nu_1$ bands of the $NT_3$ molecule, 17: 32048 (TID-19213)
**RAO, K. Narahari**, Six-meter focal length Ebert-type infrared spectrograph. I and II, 17: 32341 (TID-19175)
**RAO, K. V. Narasinga**, Gyro-interaction of microwaves in magneto plasma in atmospheric gases, 17: 33215
**RAO, N. M.**, Radiochemical studies of spontaneous fission of U-238, 17: 33109
**RAO, N. S.**, Analysis of radiation-induced genetic damage in seeds, 17: 31869
**RAPOPORT, I. D.**, Nuclear particle spectrum at 3260 m altitude, 17: 32892
**RAPSON, W. H.**, Grafting polymers onto cellulose by high-energy radiation. II., 17: 31808
**RATHJE, J.**, Photomultipliers with optical impulses, 17: 32335 (DESY-A2.99)
**RAUSCHE, A.**, Slowing down of fast electrons, 17: 32826
**RAUSHENBAKH, M. O.**, Transformation of hemopoietic cells in irradiated dogs, 17: 31969
**RAVERA, O.**, Manganese-54 concentration from fallout in Italian mollusks, 17: 31847
**RAWSON, H.**, Effect on $UO_2$ of controlling grain growth during sintering, 17: 32635
**RAWSON, N.**, High melting-point glasses containing $UO_2$, 17: 32506
**RAY, D. K.**, Crystalline electric field effects on rare earth ions. II., 17: 32090
**RAY, J. A.**, Cross sections, 17: 33155 (ORNL-3472(p.56-69))
**RAYBURN, T. F.**, Vacuum arc research, 17: 33154 (ORNL-3472(p.50-5))
**REAGAN, D. D.**, High-current linear induction accelerator for electrons, 17: 33119 (UCRL-7408)
**REARDON, W. A.**, Idealized Pu dissolvers, 17: 32895 (HW-SA-2999)
**REASBECK, P.**, Radiative capture of heavy ions, 17: 33060
**REBER, J. D.**, Optimum channel width for single-channel analysis, 17: 32429
**REBOUL, T. Todd**, Continuous plasma acceleration, 17: 33204
**RECHNITZ, G. A.**, Direct determination of some alkali metal ions, 17: 31998
**REDMAN, J. D.**, Vacuum systems, techniques, and material studies, 17: 33159 (ORNL-3472(p.107-18))
**REED, Glenn A.**, Refueling experience at Yankee plant, 17: 33355
**REED, Jack W.**, Sedan long range blast propagation, 17: 31801 (PNE-202F)
**REED-HILL, R. E.**, Determination of alpha Zr {11$\bar{2}$1} twinning elements, 17: 32632
**REEVE, K. D.**, Non-uniform shrinkage in sintering, 17: 32582
**REEVES, Hubert**, Late stages of stellar evolution, 17: 32850
**REICH, C. W.**, Analysis of directional-correlation data, 17: 33031
**REICHEL, H.**, Diffusion of fission products through graphite, 17: 33273
**REICHEL, H.**, Release of fission products from UC–ZrC fuel inserts, 17: 33272
**REINHARD, G.**, Uranium multiple fission. V., 17: 33030
**REMAEV, V. V.**, Formation of isomer and ground states of nuclei in (p,n) reaction, 17: 33072
**REMICK, Forrest J.**, Operating university reactors within regulations, 17: 33382
**RENGEL, J. C.**, Future of large reactors, 17: 33344
**REPINA, V. A.**, Integral absorbed dose in Ra therapy, 17: 31906
**RESHETOVA, L. N.**, Formation of isomer and ground states of nuclei in (p,n) reaction, 17: 33072
**RESHOTKO, Eli**, Resonance in cold multiconstituent plasma at arbitrary orientation to magnetic field, 17: 33148 (NASA-TN-D-1875)
**RESIBOIS, P.**, Equivalence between two generalized master equations, 17: 33232
**REULAND, Robert J.**, Activation analysis for Na in Na–W bronzes, 17: 31994

**REUSCHER, J. A.,** Liquid densitometer with improved sensitivity, 17: 32386
**REYNOLDS, Joan H.,** Prog. rpt. on nuclear engineering, 9–12/62, 17: 31793 (BNL-782)
**REYNOLDS, S. D., Jr.,** Development of Ni alloy surfacing techniques, 17: 32509
**REZNIK, B. D.,** Prog. rpt. on direct conversion of $UF_4$ to UC, final, 7/61–7/62, 17: 32182 (GTR-17)
**RHODES, C. G.,** Transformation $\gamma$–$\gamma'$ in U–Mo, 17: 32605
**RICATEAU, P.,** MHD conversion in inhomogeneous flow, 17: 33219
**RICHARDSON, D. M.,** Vacuum systems, techniques, and material studies, 17: 33159 (ORNL-3472(p.107-18))
**RICHARDSON, Gerald L.,** Radioactive waste fractionization and packaging, 17: 33395 (HW-SA-2786)
**RICHMOND, C. R.,** Electronic processing and analysis of metabolic data, 17: 31815 (LADC-5627)
**RICHTER, H.,** Welds of Nb-containing Zr alloys, 17: 32496
**RIDEOUT, S. P.,** Stress corrosion cracking of Type 304 stainless steel, 17: 32516 (DPSPU-62-30-26)
**RIEGER, G. F.,** Superheat fuel design, 17: 33239 (GEAP-4244)
**RIETJENS, L. H. Th.,** Decrease of plasma loss in stellarator, 17: 33145 (MATT-157)
**RILEY, K. F.,** $K^-$-p total cross section between 2.7 and 5.2 Bev/c, 17: 32897 (BNL-6962)
**RIMINI, A.,** Precisions in operation of analog-to-digital conversion, 17: 32408
**RIND, Emanuel,** Laboratory for space radiation effects, 17: 32699
**RING, T.,** Precision auxiliary bias unit, 17: 32355
**RIPEANU, S.,** Structure and magnetic properties of Co layers, 17: 32579
**RISHBETH, H.,** Electron density profile in the F2 layer, 17: 32870
**RISTIC, M. M.,** High-temperature reaction in $UO_2$–$TiO_2$ system, 17: 32656
**RISTIC, M. M.,** Procedure for $UO_2$ sintering, 17: 32658
**RISTIC, M. M.,** Vibratory compaction of $UO_2$ powder, 17: 32552
**RISTINEN, R. A.,** Decay of V-48, 17: 33056
**RITCHIE, R. H.,** Emission spectra of electron-irradiated metal foils, 17: 32669 (ORNL-3450)
**RITTENBERG, Marvin B.,** Immunologic unresponsiveness in adult, x-irradiated rabbits, 17: 31914
**RIVES, J. E.,** Energy levels in square well with hard core, 17: 33001 (CONF-128-1)
**RIVKIN, S. L.,** Determination of specific volume of $D_2O$, 17: 32060
**ROBELOTTO, S.,** Electron beam welding of refractory materials, 17: 32557
**ROBERTS, Francis P.,** Adsorption of Ce values from solutions, 17: 32204
**ROBERTS, John E.,** Trichloroacetates of La, Nd, and Dy, 17: 32069
**ROBERTS, W. A.,** Mass distribution and throwout studies, Project Sedan, 17: 31802 (PNE-217F)
**ROBERTSON, J. A. L.,** Interesting developments in $UO_2$ technology, 17: 33274
**ROBERTSON, J. A. L.,** Thermal conductivity of $UO_2$ under irradiation, 17: 32661 (CRDC-1143)
**ROBERTSON, J. A. L.,** Thermal conductivity of $UO_2$ up to 1200°C, 17: 32698
**ROBERTSON, R. E.,** Solvolysis in light and heavy water. V., 17: 32063
**ROBINS, J. L.,** Mass peaks in mass spectrometer, 17: 32345
**ROBINSON, C. C.,** Nucleation characteristics of cryogenic liquids, 17: 32828
**ROBKIN, M. A.,** Prog. rpt. on Pu recycle, 4–6/63, 17: 33240 (GEAP-4303)
**ROBSON, William Selwyn,** Improvements in reactor fuel elements, 17: 33284
**ROBSON, William Selwyn,** Improvements in reactor fuel elements, 17: 33285
**ROCCO, Gregory G.,** Distribution of Cs-137 and Sr-90 in the oceans, 17: 32273
**ROCHER, Josel,** Electron magnetic resonance in $\gamma$-irradiated $Na_2S_2O_3$, 17: 32166
**RODDA, J. L.,** Transistorized time-amplitude converter, 17: 32358
**RODGERS, J. W.,** Silicon p-n junction radiation detectors, 17: 32458
**RODINOS, M.,** Core component design for minimum cost, 17: 33282
**ROETHER, W.,** Seasonal variations of bomb tritium in rain, 17: 32281
**ROGACHEVA, L. S.,** Transformation of hemopoietic cells in irradiated dogs, 17: 31969
**ROGACHEVA, S. A.,** Therapeutic action of highly polymerized DNA in radiation sickness, 17: 31973
**ROGERS, D. R.,** Indirect determination of Th with EDTA, 17: 31993
**ROGERS, J. T.,** Polarization of neutrons from D(d,n)$He^3$ reaction, 17: 32996 (CONF-46-78)
**ROGERS, P. S.,** Improving duty cycle of Harwell synchrocyclotron, 17: 33132
**ROHRBACH, Edward J.,** Radiation vs. materials. II., 17: 32683
**ROIZEN, I. I.,** Describing interaction of high-energy particles, 17: 32952
**ROKHLIN, L. L.,** Neodymium solution in Mg, 17: 32594
**ROLLIER, M. A.,** Low $\gamma$ and neutron fluxes chemical dosimetry, 17: 32460
**ROMANOV, Yu. F.,** Characteristics of ternary fission in U and Pu, 17: 33019
**ROMANS, W. E.,** Recording of scintillation scan data, 17: 32351
**ROMANTSEV, E. F.,** Radiation and chemical protection, 17: 31956
**ROMERO, Jacob B.,** Fuel containment in gaseous-core nuclear rocket, 17: 33394
**ROOS, B. W.,** Expansions associated with pair of singular first-order differential equations, 17: 32479
**ROPP, Gus A.,** Isotope exchange of deuteriosulfuric acid with pivalic acid, 17: 32151
**RORABACHER, D. B.,** Multidentate ligand kinetics. III., 17: 32067
**ROSE, D. C.,** Satellite measurements in "Starfish" artificial radiation zone, 17: 32860
**ROSE, John E.,** Simple test for leaking radium sources, 17: 31880
**ROSE, R. M.,** Niobium–Th eutectic alloy as superconductor, 17: 32650
**ROSE, Raymond G.,** Distribution of P-32 in phantoms, 17: 31876
**ROSENBERG, A. F.,** Thorium oxide—diffusion of oxygen in, compatibility with borides, and coating borides, 17: 32564 (ASD-TDR-63-635)
**ROSENFELD, Arthur H.,** Baryon spectroscopy, 17: 32918 (UCRL-10897)
**ROSENFIELD, A. R.,** Interstitial solid solutions in bcc metals, 17: 32618
**ROSENSTEIN, A.,** Low $\gamma$ and neutron fluxes chemical dosimetry, 17: 32460
**ROSIN, Seymour,** Illumination of 80-in. bubble chamber, 17: 32397 (BNL-6848)
**ROSTOMYAN, B. O.,** Nuclear particle spectrum at 3260 m altitude, 17: 32892
**ROTARIU, George J.,** Radioisotope application to coal, 17: 32320 (CONF-124-2)
**ROTH, R. S.,** Polymorphism of $ABO_3$-type rare earth borate solid solutions, 17: 32124
**ROTHBERG, Joseph E.,** Muon capture in H, 17: 33002 (NEVIS-116)
**ROTHE, William E.,** Radioprotection by pressor amidines, 17: 31948
**ROTHMANN, W.,** Fluorescence spectrometric determination of Ta and Nb, 17: 32007
**ROTONDI, E.,** Response to fast neutrons of $BF_3$ counter, 17: 32432
**ROULLIAY, R.,** Beryllium oxide bricks as neutron reflectors, 17: 33275
**ROWE, E. M.,** Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)
**ROY, C. L.,** X-ray non-diagram lines, 17: 32777
**ROY, Ph.,** Recoil protons from e-p scattering at 950 Mev, 17: 32905 (LAL-1072)
**ROY, R. R.,** Fission fragment kinetic energy as function of prompt $\gamma$ rays, 17: 33093
**ROY, Rustum,** Phase transitions in $LiAl_5O_8$, 17: 32599
**ROZANOVA, V. N.,** Solidification of radioactive waste solutions, 17: 33401
**RUDY, E.,** Stability of $UC_2$ and C-stable regions in systems of UC with ZrC, HfC, NbC, and TaC, 17: 32617
**RUDY, E.,** Systems Th–Mo–C and U–Mo–C, 17: 32616
**RUEDL, E.,** Radiation damage in alpha U, 17: 32681
**RUGGE, Henry F.,** Instability of alternating-current positive column in magnetic field, 17: 33161 (UCRL-10698)
**RUIJGROK, Th. W.,** Quasi-elastic magnetic scattering of slow neutrons, 17: 32985
**RUKHADZE, A. A.,** Instability of MHD compressed fluid, 17: 32812
**RUKHADZE, A. A.,** Oscillations of low-pressure inhomogeneous plasma, 17: 33189
**RUSHBROOKE, G. S.,** Hyperfine-chain equation of state of hard-sphere gas, 17: 32778
**RUSI, A.,** Organic solvents in cation exchange, 17: 32092
**RUSOV, C.,** Therapeutic effect of P-32 on leucosis in poultry, 17: 31825
**RUSSELL, F. M.,** Fixed-frequency, fixed-field, high-energy accelerator, 17: 33128
**RUSSELL, F. M.,** Improving duty cycle of Harwell synchrocyclotron, 17: 33132
**RUSSELL, G. R.,** Performance and analysis of a crossed-field accelerator,

17: 32835
**RUSSELL, Gary R.**, Electron-ion reaction rate theory, 17: 33208
**RUSSELL, Gary R.**, Electron-ion reaction rate theory, 17: 33208
**RUSSELL, John L., Jr.**, Theory of pulsed neutron source measurements, 17: 32894 (CONF-39-47)
**RUSSELL, L. E.**, Sintering behavior and stability of $(PuU)O_2$ solid solutions, 17: 32634
**RUSSELL, R. B.**, Prog. rpt. on $\beta$ treatment of U, 11/59–8/60, 17: 32538 (NMI-2801)
**RUSSELL, R. B.**, Prog. rpt. on $\beta$ treatment of U, 8–11/61, 17: 32539 (NMI-2805)
**RUSTON, W. R.**, Diffusion of fission products through graphite, 17: 33273
**RUSTON, W. R.**, Release of fission products from UC–ZrC fuel inserts, 17: 33272
**RUSU, Gh. Ilie**, Shell structure and Roche nuclear density, 17: 33010
**RUTHERFORD, P.**, Quasi-linear theory of plasma instabilities, 17: 33146 (MATT-169)
**RUTHERFORD, P. H.**, Two-particle correlation function for unstable plasma, 17: 33173
**RUTKEVICH, N. Ya.**, Reaction $(p,\alpha)$ at 20 Mev, 17: 33070
**RUZICKA, Jiri**, Production of heavy water, 17: 32136
**RYABCHENKO, N. I.**, Study of DNA radiation damage by thermal strand separation. II., 17: 31922
**RYABOV, A. N.**, Solid Ru tetrachloride, 17: 32122
**RYAN, J. P.**, Ceramic carrier for radioisotopes, 17: 32327
**RYAN, Joseph R.**, Zirconia phase changes and solid solution reactions, 17: 32653
**RYBAKOV, B. V.**, Ground state of Be-6, 17: 33078
**RYBAKOV, V. N.**, Secondary D and T capture reactions, 17: 33075
**RYCHEN, H. U.**, Experiences with 31-Mev betatron, 17: 32609
**RYGAERT, J.**, Diffusion of fission products through graphite, 17: 33273
**RYGAERT, J.**, Release of fission products from UC–ZrC fuel inserts, 17: 33272

# S

**SABAU, C.**, Organic solvents in cation exchange, 17: 32092
**SACCHETTI, N.**, Superconducting magnets, 17: 32712 (LNF-63/26)
**SACERDOTI, G.**, Linear theory of accelerators. II., 17: 33117 (LNF-63/18)
**SACERDOTI, G.**, Superconducting magnets, 17: 32712 (LNF-63/26)
**SACHS, Martin**, Excitation functions for Li-6 induced reactions on Au-197, 17: 33038
**SADOVSKII, A. P.**, Reciprocal system of Na and K pyrophosphates and fluorides, 17: 32114
**SAINT-PAUL, Raymond G.**, Fortran program for unit cell nuclear design calculations, 17: 33238 (CVNA-146(Vols.I & II))
**ST. PIERRE, L. E.**, Further NMR studies of polydimethylsiloxanes, 17: 32683
**SAKURADA, Ichiro**, Radiation copolymerization to cellulose. II., 17: 32676
**SALAMATIN, B. A.**, Behavior of radioisotopes incorporated in glass blocks, 17: 33404
**SALMEN, W. J.**, Tensile properties of Be, 17: 32645
**SALMON, G. L.**, Extended duty cycle from Harwell synchrocyclotron, 17: 33131
**SAMOILOV, L. N.**, Atmospheric contamination over Atlantic Ocean in 1961, 17: 31844
**SAMOILOV, V. M.**, Solid Ru tetrachloride, 17: 32122
**SAMOKHVALOVA, N. S.**, Chromosome aberrations as function of irradiation intensity, 17: 31902
**SAMSONOV, G. V.**, Behavior of B compound irradiated with neutrons, 17: 32157
**SAMSONOV, G. V.**, Classification of hydrides, 17: 32108
**SAMUELS, G.**, Heat transfer and fluid flow, 17: 33326 (ORNL-3445(p.298-328))
**SAMUELS, Larry D.**, Environmental exposure to Ru in drinking water, 17: 32314
**SANCHEZ, Gerardo Pardo**, Nuclear processes produced by bombardment of acetylene with $He^3$ beam, 17: 32153 (JEN-119-DF/I-36)
**SANDAGE, Allan R.**, Optical identification of 3C 48, 3C 196, and 3C 286, 17: 32847
**SANGAL, Satendra P.**, Lanthanum–thoron chelate, 17: 31983
**SANGREN, W. C.**, Expansions associated with pair of singular first-order differential equations, 17: 32479
**SANNA, G.**, Superconducting magnets, 17: 32712 (LNF-63/26)
**SANO, T.**, Formation of $UC_{1-x}$ O, and $UC_{1-x}$ $N_x$, 17: 32132
**SANTHANAM, T. S.**, Symmetries shared by strong and weak interactions, 17: 32936
**SARADA, Kum. G.**, Active particles in fallout from weapon tests, 17: 32283 (AEET/AM/34)
**SARGENT, Wallace L. W.**, Ultraviolet spectrum of 3 Centauri A, 17: 32851
**SATCHLER, G. R.**, Elastic scattering from odd-mass nuclei, 17: 33051
**SATTLER, Erich**, Obtaining comparable photographs of oscilloscope display, 17: 32464
**SATYA MURTHY, N. S.**, Neutron studies of nonstoichiometric metal hydrides, 17: 32580
**SAUNIER, N.**, Two-dimensional registration in coincidence, 17: 32423
**SAVAGE, H. W.**, Fueled-graphite systems, 17: 33322 (ORNL-3445(p.138-98))
**SAVAGE, H. W.**, Moderator materials, 17: 33324 (ORNL-3445(p.218-50))
**SAVARIRAJ, G. A.**, Angular distribution of deuterons in $Li^7(\alpha,d_0)Be^9$, 17: 33014
**SAVCHENKO, V. I.**, Magnesium cermets and Mg–Be alloys, 17: 32553
**SAVEDOFF, M.**, Total energy of white dwarf models, 17: 32858
**SAVITSKII, E. M.**, Rare earth alloys, 17: 32648
**SAWYER, G. A.**, Magnetic field in Scylla I theta pinch, 17: 33178
**SAWYER, W. A.**, Economic manufacture of power reactor fuel, 17: 33358
**SAYERS, J. B.**, Irradiation effects in U and Pu ceramics, 17: 33264
**SCADRON, M. D.**, Thermocouples for high gas temperature measurement, 17: 32644
**SCANLON, Paul W.**, Test of divided-dose irradiation, 17: 31873
**SCHAEFER, L.**, Manufacture and use of UC for fuel elements, 17: 33248
**SCHAIRER, Lloyd A.**, Nuclear volumes, chromosome numbers, and radiosensitivities, 17: 31949
**SCHALLOPP, B.**, Neutron-absorbing materials for reactor control, 17: 32493
**SCHEEPMAKER, A.**, Gamma ray transitions in Cl-35, 17: 33059
**SCHIFFERSTEIN, K.**, Diffusion of fission products through graphite, 17: 33273
**SCHIFFERSTEIN, K.**, Release of fission products from UC–ZrC fuel inserts, 17: 33272
**SCHILLING, W.**, Device for detection of solidified air on cold surfaces, 17: 32353
**SCHINDLER, A. I.**, Effects of neutron irradiation on magnetic properties of alloys, 17: 32692
**SCHMID, E.**, Scattering of He-3 by $\alpha$ particles, 17: 32993 (BNL-6955)
**SCHMID, Erich**, Radiation effects on plastic deformation of metals, 17: 32684
**SCHMIDT, H.**, Methane flow counter, 17: 32019
**SCHMIDT, L.**, Synthesis of $C^{14}$-labeled organic compounds using vacuum apparatus, 17: 32150
**SCHNEIDER, Carol**, Sensitivity of irradiated mice to bacterial endotoxin, 17: 31921
**SCHNEIDER, Petr**, Thermionic properties of thoriated W, 17: 32639
**SCHNEIDER, Volker**, Bibliography on Au-198 in medicine, 17: 31814 (KFK-143)
**SCHOLZ, S.**, Sintering of Hf, Zr, and Ta carbides, 17: 32583
**SCHRACK, R. A.**, Photomeson studies of nuclear sizes, 17: 33106
**SCHREIBER, B.**, Beta radioactivity of plankton in Adriatic and Ligurian seas, 17: 31845
**SCHREMP, E. J.**, Baryon doublets and neutrino doublets. II., 17: 32716 (NP-12996(p.23-8))
**SCHREMP, E. J.**, Quaternion approach to elementary particle theory. II., 17: 32715 (NP-12996(p.1-22))
**SCHROER, B.**, Infra-particles in quantum field theory, 17: 32925
**SCHROLLER, R.**, Sand moisture measurements by BF, counter, 17: 32018
**SCHUCH, A. F.**, Phenomena along the hcp-bcc transition line of He-3 and He-4, 17: 32776
**SCHULTZ, F. V.**, Electron density perturbations from mixing of two different plasmas, 17: 33193
**SCHULTZ, J. W.**, Infrared modulation by free carrier absorption, 17: 32729 (SCR-636)
**SCHULTZE, M. O.**, Problems of tritiation of S-(1,2-dichlorovinyl)-L,

cysteine, 17: 32143
**SCHUMANN, G.,** Seasonal variations of bomb tritium in rain, 17: 32281
**SCHUNK, Herbert,** Carotid compression device for prevention of radiation hazard, 17: 32306
**SCHUTZSACK, U.,** Food preservation by ionizing radiation, 17: 32324
**SCHWARZ, H.,** Chromates(V) of rare earths. I., 17: 32102
**SCHWARZ, H.,** Chromates(V) of rare earths. II., 17: 32103
**SCHWARZ, H.,** Chromates(V) of rare earths. III., 17: 32104
**SCHWARZ, H.,** Chromates(V) of rare earths. IV., 17: 32105
**SCLAR, N.,** Rare earth nitride semiconductors, 17: 32652
**SCOTT, P. A.,** Primary coolant pump for PRTR, 17: 33370 (HW-SA-3098)
**SEAGONDOLLAR, L. W.,** Note on angular distribution analysis, 17: 33033
**SEARCY, Alan W.,** High-temperature chemistry under-developed areas, 17: 31981 (UCRL-10882)
**SEDLAKOVA, L.,** Composition of stoichiometric $UO_2$, 17: 32131
**SEDOV, B. M.,** Four-level optical generator, 17: 32804
**SEELEY, Thomas Arthur,** Improvements in reactor fuel elements, 17: 33284
**SEIBEL, G.,** Analysis of Fe and lime in drill core samples, 17: 32016
**SEIDLER, H.,** Strontium-90 contamination of men caused by food uptake, 17: 31846
**SEIFER, G. B.,** Thermal decomposition of Ce ferrocyanides, 17: 32117
**SEIFERT, H. S.,** Propulsion for space vehicles, 17: 33387
**SEIYAMA, Takeyoshi,** Studies on fallout particles. III., 17: 32302
**SELEBORG, Madeleine,** Bibliography on uranates and related U compounds, 17: 32049 (VDIT-77)
**SELF, S. A.,** Theory of r-f confinement, 17: 33180
**SELIVANOVA, L. N.,** Reaction of blood system of dogs in chronic Sr-90 irradiation, 17: 31930
**SELIVERSTOVA, L. A.,** Regeneration of irradiated cells and type of energy metabolism, 17: 31890
**SEN, Amiya K.,** Stability of hydromagnetic Kelvin-Helmholtz discontinuity, 17: 32774
**SENKOWSKI, T.,** Szilard-Chalmers effect in complex compounds. I., 17: 32168
**SERBANESCU, O.,** Beta radioactivity of zooplankton of Black Sea, 17: 31843
**SERGEL, O. S.,** Blood changes in treatment of capillary hemangioma, 17: 31905
**SERVANT, Roger,** Electron magnetic resonance in γ-irradiated $Na_2S_2O_3$, 17: 32166
**SESHADRI, S. R.,** Radiation from electromagnetic source in half-space of compressible plasma-surface waves, 17: 33141 (AD-410077)
**SESINI, R.,** Process for producing little $UO_2$ sintered spheres, 17: 32556
**SESSLER, A. M.,** Beta spectrometer with reduced spherical aberration, 17: 32430
**SESSLER, Andrew M.,** Bremsstrahlung in dense plasma, 17: 33177
**SETLOW, Richard,** Ultraviolet-light inactivation of systems containing 5-bromouracil-substituted DNA. I., 17: 31885
**SETLOW, Richard,** Ultraviolet-light inactivation of systems containing 5-bromouracil-substituted DNA. II., 17: 31886
**SETSER, James L.,** Neutron activation determination of Zr and Hf, 17: 31986 (TID-19179)
**SETTI, R. Levi,** Interactions of heavy nuclei with energy $>10^{12}$ev/nucleon, 17: 32893
**SEVAST'YANOV, Yu. G.,** Thermal and radiation stability of aromatic compounds, 17: 32156
**SHABER, Gary S.,** Fibrinogen turnover before and after x irradiation in the rat, 17: 31916
**SHAEFFER, Joseph R.,** Participation of coagulation mechanism in tumor localization of $I^{131}$-labeled fibrinogen, 17: 31820 (UR-630)
**SHAFRINA, K. A.,** Reactivity of animals subjected to radiation, 17: 31974
**SHAIR, F. H.,** Performance of MHD generators, 17: 32817
**SHAPIRO, Charles S.,** Velocity polynomials in neutron thermalization, 17: 32973 (CONF-39-46)
**SHAPIRO, I. M.,** Influence of radiation-induced chromosomal aberrations on viability of cells, 17: 31897
**SHAPIRO, N. I.,** Action of protective substances in irradiation of tissue, 17: 31939
**SHAPIRO, Sidney,** Nuclear magnetic resonance in metal hexaborides, 17: 32083
**SHARNOFF, Mark,** Magnetic resonance studies of unpaired atoms in solid $D_2$, 17: 32042 (TID-19123)
**SHARPE, Roy Samuel,** Ultrasonic methods of testing, 17: 32263
**SHATALOV, A. Yo,** Anodic oxidation of Zr in electrolytes, 17: 32528
**SHCHELOKOV, R. N.,** Complex pentacid–uranyl oxalate–halide compounds, 17: 32119
**SHCHERBAKOV, Yu. A.,** Formation of mesic He in mixture of He and H, 17: 33080
**SHCHERBAKOVA, M. N.,** Ionization-momentum relation for particles in relativistic region, 17: 32453
**SHCHERBOVA, E. N.,** Bone marrow destruction in γ irradiation, 17: 31931
**SHEEHAN, T. V.,** Engineering, 17: 31799 (BNL-782(p.92-4))
**SHEPSHELEVICH, L. L.,** Transformation of hemopoietic cells in irradiated dogs, 17: 31969
**SHERWOOD, W. A.,** High-current linear induction accelerator for electrons, 17: 33119 (UCRL-7408)
**SHEWCHUCK, Sergey,** Sintering of single- and two-component crystalline powder, 17: 32542 (UCRL-Trans-953(L))
**SHIH, Hsueh-dan,** Ambiguity in assigning phase shift of N-d scattering, 17: 32946
**SHILOV, V. M.,** Disturbance of immunity during affection by ionizing radiations, 17: 31977
**SHIMA, Yo'akov,** Plasma theory and computation, 17: 33157 (ORNL-3472 (p.75-83))
**SHIMANOUCHI, Takehiko,** Normal vibrations of glycine and deuterated glycine molecules, 17: 32146
**SHIMCHAK, R. A.,** Secondary D and T capture reactions, 17: 33075
**SHIMOKAWA, Junichi,** Reprocessing of $UO_2$-dispersed graphite fuels. II., 17: 32200
**SHIPLEY, E. D.,** Very high-energy injection into magnetic mirror, 17: 33160 (ORNL-3472(p.119-20))
**SHIPMAN, J. J.,** Infrared spectra for PVC and deuterated analogs, 17: 32606
**SHIRAI, Shogo,** Studies on fallout particles. III., 17: 32302
**SHIRANE, G.,** Magnetic structures in the MnSb–CrSb system, 17: 32622
**SHIROKOV, Yu. M.,** Invariant parametrization of local operators, 17: 32953
**SHKAPINA, V. A.,** Reaction of N metabolism during radiation sickness, 17: 31975
**SHLIOMIS, M. I.,** Oscillation perturbations in conducting fluid, 17: 32782
**SHMAKOVA, N. L.,** Cytological analysis of action of high-energy protons. II., 17: 31942
**SHMIDT, A. A.,** Biochemical disturbances caused by radiation in organism, 17: 31838
**SHOBE, L. R.,** Experimental stress analysis of nuclear reactor pressure vessel, 17: 33252
**SHOBER, F. R.,** Creep and tensile properties of Nb-base alloys, 17: 32561 (CONF-53-5)
**SHOEMAKER, N. F.,** Differential dose albedo of γ rays, 17: 33225
**SHPINEL, V. S.,** Resonance γ absorption in Ba, Sr, and Ca stannites, 17: 32107
**SHRAYBER, M. I.,** Injuries from atomic bomb explosions, 17: 32295 (JPRS-20511)
**SHUBNYI, Yu. K.,** Resonance scattering of γ quanta on Cu-65 and Ti-46, 17: 33076
**SHULTS, M. M.,** Lithium silicate glasses containing oxides of Y, 17: 32084
**SHULTS, M. M.,** Properties of alkali silicate glasses, 17: 32095
**SHULTS, M. M.,** Properties of $Li_2O$–$Cs_2O$–$La_2O_3$–$SiO_2$ glasses, 17: 32096
**SHULTS, M. M.,** Properties of Li silicate glasses, 17: 32097
**SHULTS, M. M.,** Properties of polycomponent Li silicate glasses, 17: 32098
**SIDHU, S. S.,** Neutron studies of nonstoichiometric metal hydrides, 17: 32580
**SIDOROV, B. N.,** Radiation analysis of chromosome discreteness in autoreproduction, 17: 31935
**SIDOROV, L. N.,** Vapor pressure of $ZrF_4$, 17: 32116
**SIDOROV, V. A.,** Ground state of Be-6, 17: 33078
**SIEBERT, K.,** Strontium-90 contamination of men caused by food uptake, 17: 31846
**SIEGEL, R. T.,** Improved noble liquid scintillation counter, 17: 32449
**SIEGEL, Robert,** Forced convection in channel with wall heat capacity, 17: 32256
**SIEVERS, Robert E.,** Gas phase chromatography of metal chelates, 17: 32068

**SIKOV, Melvin R.**, Plasma constituents produced by whole-body irradiation, 17: 31875
**SILBERMAN, E.**, Spectrography of U and Ca silicates, 17: 32739
**SILIN, V. P.**, Oscillations of low-pressure inhomogeneous plasma, 17: 33189
**SILVER, M. D.**, Lattice parameters of Hf–O alloys, 17: 32630
**SILVESTER, D. R.**, Corrosion of Zr and its alloys, 17: 32520
**SILVESTRI, M.**, Competitivity, 17: 33334
**SILVESTRINI, V.**, Circuit to measure maximum energy of bremsstrahlung, 17: 32401 (LNF-63/17)
**SIMMONS, G. J.**, Mathematical model for associative memory, 17: 32475 (SCR-641)
**SIMON, H. A.**, Laminar free convection in $CO_2$, 17: 32258
**SIMONOF, George S.**, Multiparameter pulse-height recording system, 17: 32343 (UCRL-10874)
**SIMS, R. T.**, Another variable to be observed in autoradiographs, 17: 31834
**SINGER, L.**, Bone Ca and Sr discrimination, 17: 31841
**SINGH, M. P.**, Motion of non-conducting sphere through conducting fluid in magnetic cross-field, 17: 32783
**SINGH, M. P.**, Motion of sphere through conducting fluid in presence of magnetic field, 17: 32784
**SIPE, C. R.**, Lymphocyte production measured by extracorporeal irradiation, 17: 31852 (BNL-7137)
**SIROTA, Paul G.**, Distribution of P-32 in phantoms, 17: 31876
**SISMAN, O.**, Clad fuel development, 17: 33323 (ORNL-3445(p.199-217))
**SISMAN, O.**, Fueled-graphite systems, 17: 33322 (ORNL-3445(p.138-98))
**SISMAN, O.**, Irradiation testing of GCR components and materials, 17: 33320 (ORNL-3445(p.63-108))
**SJOESTRAND, N. G.**, Formation of neutron beams with special properties, 17: 32978
**SKAGGS, Lester S.**, Radiation therapy with high-energy electrons, 17: 31870
**SKALAFURIS, Angelo J.**, Structure of shock front in atomic H. I., 17: 32744
**SKARSVAG, K.**, Slow neutron fission of U-235, 17: 33042
**SKRABEK, E. A.**, Laves phases containing lanthanides combined with Fe and Co, 17: 32819
**SKURNIK, E. Z.**, First excited states of Re-185 and Re-187, 17: 33040
**SLAUGHTER, G. M.**, Brazing graphite to itself, 17: 32547
**SLAVIN, Walter**, Determination of Al by atomic absorption spectrophotometry, 17: 32028
**SLIPPY, W. A., Jr.**, Determination of alpha Zr $\{11\bar{2}1\}$ twinning elements, 17: 32632
**SLIZYNSKA, H.**, Mutagenic effects of x rays in spermatogenesis of Drosophila, 17: 31892
**SLOVACEK, R. E.**, Asymptotic neutron spectra in multiplying media, 17: 32971 (CONF-11-6)
**SMELTZER, W. W.**, Diffusion of O in Hf, 17: 32601
**SMILANSKY, U.**, Measurements of gyromagnetic ratios, 17: 32771
**SMIRENKIN, G. N.**, Formula for average number of fission neutrons, 17: 33016
**SMIRNOVA, I. B.**, Influence of radiation-induced chromosomal aberrations on viability of cells, 17: 31897
**SMIRNOV-AVERIN, A. P.**, Thermal and radiation stability of aromatic compounds, 17: 32156
**SMITH, A. B.**, Fast neutron scattering from Ta-181, 17: 32991 (ANL-6727)
**SMITH, Alan R.**, Terrestrial gamma radioactivity, 17: 32264 (UCRL-10636)
**SMITH, B. C.**, Reactions of $UCl_4$ with tertiary phosphines, 17: 32064
**SMITH, Ernest**, Improvements in reactor fuel elements, 17: 33284
**SMITH, Ernest**, Improvements in nuclear fuel elements, 17: 33286
**SMITH, G. D.**, Absorption of $Sr^{90}SO_4$ from the lung, 17: 31835
**SMITH, Harold H.**, Corn seeds affected by heavy cosmic particles, 17: 31947
**SMITH, J. Chandler**, Radiation pneumonitis, 17: 31965
**SMITH, J. E.**, Experimental stress analysis of nuclear reactor pressure vessel, 17: 33252
**SMITH, Joseph H.**, Flux-to-dose rate conversion factors for $\gamma$ exposure, 17: 31812
**SMITH, Linda Lou**, Solvent extraction data for Pu, 17: 32190 (DP-700)
**SMITH, Willie W.**, Sensitivity of irradiated mice to bacterial endotoxin, 17: 31921
**SMITHER, R. K.**, Observation of Be-8 in ground state, 17: 33054
**SMOOT, Thomas W.**, Zirconia phase changes and solid solution reactions, 17: 32653
**SMY, P. R.**, Electrical impedance of electrodes immersed in moving plasma, 17: 33164
**SNOWDON, S. C.**, Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)
**SNOWDON, S. C.**, Spiral-sector FFAG magnet design, 17: 33115 (CONF-125-5)
**SNYDER, H. J.**, ML-1 reactor stability tests, 17: 33302 (AGN-TM-403)
**SNYDER, William T.**, Slug flow heat transfer in an eccentric annulus, 17: 32252
**SOBAJIC, M. V.**, G-M counters as switching elements, 17: 32425
**SOBINYAKOV, V. A.**, Nuclear particle spectrum at 3260 m altitude, 17: 32892
**SOCKY, Richard B.**, Ultrasonics in fatigue testing, 17: 32262 (HW-SA-2927)
**SODAN, Horst**, Decay of Tm-168, 17: 33008 (ZFK-PHA-8)
**SOENO, Ko**, Phase change and heat treatment of U–Mo alloys, 17: 32619
**SOKOLOV, N. N.**, Radiation analysis of chromosome discreteness in autoreproduction, 17: 31935
**SOKOLOV, V. V.**, Meson pair production in electron-positron collisions, 17: 32958
**SOKOLOVA, T. D.**, Reactions of Sc chlorides with ethylenediamine, 17: 32147
**SOKURSKI, Yu. N.**, Surface properties of alpha U. I., 17: 32602
**SOLARZ, A. K.**, Dyadic dominance-submission patterns in female beagle, 17: 31864 (UCD-107(p.86-97))
**SOLARZ, A. K.**, Psychological field research program, 17: 31863 (UCD-107(p.74-85))
**SOLDAINI, G.**, Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)
**SOLOV'EVA, Z. I.**, Ternary fission of U-235 with 14-Mev neutrons, 17: 33020
**SOLOV'EVA, Z. I.**, Triple fission of Pu, 17: 33079
**SOLOWAY, A. H.**, Separation of Sc-49 from Ca target, 17: 32164
**SORLIE, T.**, Prog. rpt. on Garigliano reactor, 7/63, 17: 33311 (GEAP-4306)
**SOROKIN, P. V.**, Reaction $Al^{27}(p,\alpha_0)Mg^{24}$ at 1 to 2.5 Mev, 17: 33045
**SOSOVA, V. F.**, Amount of injected $\gamma$ globulin in rabbit blood serum in radiation sickness, 17: 31972
**SPAHR, W. L.**, Development of Ni alloy surfacing techniques, 17: 32509
**SPALDING, J. F.**, Genetic effects of x irradiation of male mice, 17: 31853 (LADC-5618)
**SPANNER, J. C.**, Annular offset between metal tubes, 17: 32239
**SPANO, M. A.**, Production of electron pairs in thick converters, 17: 32713 (LNF-63/27)
**SPARKS, L. L.**, Nucleation characteristics of cryogenic liquids, 17: 32828
**SPARROW, Arnold H.**, Nuclear volumes, chromosome numbers, and radiosensitivities, 17: 31949
**SPARROW, E. M.**, Heat transfer bibliography, 17: 32257
**SPARROW, Rhoda C.**, Nuclear volumes, chromosome numbers, and radiosensitivities, 17: 31948
**SPEAR, W. G.**, Protective clothing monitoring system, 17: 32286 (HW-76351)
**SPEISER, Evelyn W.**, Electric space cruiser, 17: 32221
**SPERNER, F.**, Effects of C and N on properties of Nb, 17: 32612
**SPERONI, G.**, Vibrational assignment of isoxazole-$d_0$, 17: 32145
**SPINDLER, M. W.**, Radiation-induced vulcanization of hydrocarbon polymers. II., 17: 32167
**SPIRIDON, St.**, Organic solvents in cation exchange, 17: 32092
**SPITSIN, V.**, Sorption and migration of radioactive elements in soils, 17: 33409
**SPITSYN, V.**, Preparation and properties of Sc nitrates, 17: 32172
**SPRAGUE, Sabina**, Determination of Al by atomic absorption spectrophotometry, 17: 32028
**SPRINGER, T.**, Use of neutron optical devices on beam-hole experiments, 17: 32981
**SREEKANTAN, B. V.**, Total absorption spectrometer for Bev range, 17: 32439
**STACK, John D.**, Bremsstrahlung in dense plasma, 17: 33177
**STAERK, Heinrich**, Neutron activation determination of micro amounts of Ca, 17: 31990
**STAMBAUGH, Edgel P.**, Uranium oxide and thorium oxide recovery,

17: 32189
**STAN, Ioan,** Flux invariant, 17: 32794
**STAN, Ioan,** Stability of movement of charged particle, 17: 32793
**STAN, Ion,** Branching period of Be-8, 17: 33065
**STANDIFER, L. R.,** Materials requirements for aerospace programs, 17: 32513
**STANG, L. G., Jr.,** Hot laboratory, 17: 31797 (BNL-782(p.51-9))
**STANNET, V.,** Preparation of cellulose graft copolymers. I., 16: 31809
**STANOIU, Il.,** Preparation of scintillation discs, 17: 32406
**STARCHIK, L. P.,** Selective determination of elements on basis of ($\alpha$,n$\gamma$) ($\alpha$,p$\gamma$) reactions, 17: 32015
**STAUB, F. W.,** Prog. rpt. on two-phase flow, 4–6/63, 17: 32246 (GEAP-4251)
**STAUFFER, James L.,** Geometry of $Li_2O$ by electric deflection, 17: 32030 (AROD-006.9)
**STECHER-RASMUSSEN, F.,** Reflecting multi-channel collimators, 17: 32982
**STEEVES, A. Fremont,** Nuclear fuel element and fabrication, 17: 33294
**STEFANESCU, D.,** Preparation of scintillation discs, 17: 32406
**STEHLE, H.,** Growth of $UO_2$ grains, 17: 32586
**STENGEL, F. George,** Nuclear fuel element and fabrication, 17: 33294
**STEPANOVA, T. S.,** Bioelectric activity of uv-irradiated rabbit brain, 17: 31933
**STEPNEWSKI, D. D.,** Fission product confinement for NPR, 17: 33363 (HW-SA-2891(Rev.))
**STERLYADKINA, Z. K.,** Absorption of H by Ce–Mg alloys, 17: 32643
**STERN, [T. E.],** Generation of pseudo-random gating impulse, 17: 32344 (AEC-tr-5901)
**STEVENSON, Richard,** Paramagnetic-antiferromagnetic transition of Dy, 17: 32748
**STEWART, M. G.,** Transistorized time-amplitude converter, 17: 32358
**STEWART, W. A.,** Design of superconducting magnet, 17: 32224
**STIEDE, H.,** Sand moisture measurements by $BF_3$ counter, 17: 32018
**STIEL, Leonard I.,** Viscosity of gaseous and liquid H, 17: 32066
**STOBO, J. J.,** Properties of UC, 17: 33265
**STOCH, J.,** Determination of Th concentration using nuclear emulsion plates, 17: 31988 (CEA-tr-A-1197)
**STODDARD, J. A.,** Fission product release from PRTR rupture, 17: 33369 (HW-75045)
**STOOPS, Robert F.,** Prog. rpt. on U interstitial phases, 6/63, 17: 32486 (NCSC-2663-13)
**STOOPS, Robert F.,** Prog. rpt. on nuclear fuel, 6/63, 17: 32487 (NCSC-2981-4)
**STOTZ, K. C.,** Radiometer for plasma afterglow study, 17: 33217
**STRAILE, William E.,** Effects of heavy ions and electrons on hair depigmentation, 17: 31882
**STRATIENKO, V. A.,** Two-electron charge of low-energy protons, 17: 33077
**STRAUB, Rita F.,** *In vivo* activation in mice of C-12, N-14, and O-16, 17: 31851 (BNL-6989)
**STRAYER, R. W.,** Voltage breakdown properties of Cs films, 17: 32827
**STRELOW, F. W. E.,** Chromatographic separation of Ti from rare earths and other elements, 17: 32054
**STRELOW, F. W. E.,** Neutron activation determination of micro amounts of Ca, 17: 31990
**STRINGER, J.,** Interstitial solid solutions in bcc metals, 17: 32618
**STRONSKI, I.,** Szilard-Chalmers effect in complex compounds. I., 17: 32168
**STRUCH, H. P.,** STRZ—program for steady-state temperature distribution, 17: 32248 (RCN-16)
**STRUTINSKII, V. M.,** Calculations of nuclear fission according to liquid drop model, 17: 33009 (UCRL-Trans-978)
**STRUTSOVSKAYA, S. V.,** Integral absorbed dose in Ra therapy, 17: 31906
**STUKOVA, L. M.,** Integral absorbed dose in Ra therapy, 17: 31906
**STUPCHENKO, E. V.,** Distribution of energy according to molecular freedom in disturbed Maxwellian distribution, 17: 32811
**STURCKEN, E. F.,** Predicting physical properties in oriented metals, 17: 32631
**STURM, Bernard J.,** Preparation of sinterable BeO, 17: 32515
**SU, Lung-Tao,** Hollow superconductors in magnetic field, 17: 32809
**SUBBARAO, E. C.,** Grain growth of $Ca_{0.15}Zr_{0.85}O_{1.85}$, 17: 32135
**SUBRAMANIAN, A.,** Total absorption spectrometer for Bev range, 17: 32439
**SUDARSHAN, E. C. G.,** Axioms of relativistic quantum field theory. II., 17: 32760
**SUDDATH, J. C.,** Pot-calcination process, 17: 33403
**SUGIYAMA, H.,** Sensitivity of thorotrast-treated monkeys to staphylococcal enterotoxin, 17: 31918
**SUGUROVAS, V. (V. K. Shugurov),** Center-of-mass motion in particle system, 17: 32930
**SUKHANOV, A. D.,** Lee-Yang theory of charged vector mesons, 17: 32999
**SULYAEV, R. M.,** Formation of mesic He in mixture of He and H, 17: 33080
**SUMARUKOV, G. V.,** Efficacy of cysteamine protection of mice, 17: 31967
**SUNDIUS, G.,** Effect of x rays and botulinum toxin on survival of mice, 17: 31901
**SUU, Vu-Thi,** Increase in lysozyme activity in kidneys of irradiation chimeras, 17: 31919
**SUZUKI, A.,** Improved noble liquid scintillation counter, 17: 32449
**SUZUKI, Shigeko,** Normal vibrations of glycine and deuterated glycine molecules, 17: 32146
**SVIDERSKAYA, Z. A.,** Neodymium solution in Mg, 17: 32594
**SVIDERSKAYA, Z. A.,** Properties of Mg–Th–Mn system, 17: 32595
**SVIRIDOV, N. K.,** Blood changes in treatment of capillary hemangioma, 17: 31905
**SWANENBURG, T. J. B.,** Dynamic polarization of protons in polystyrene, 17: 32779
**SWANSON, L. W.,** Voltage breakdown properties of Cs films, 17: 32827
**SWARTZ, John M.,** Silicon rectifier developed as fast neutron subminiature dosimeter, 17: 32411
**SWENSON, D. A.,** Proton linear accelerators for energies up to 300 Mev, 17: 33113 (CONF-125-3)
**SWIFT, Ward H.,** Radioactive waste fractionization and packaging, 17: 33395 (HW-SA-2786)
**SWINDEMAN, R. W.,** Mechanical properties of INOR-8 cast metal, 17: 32573 (ORNL-TM-607)
**SYROVOI, V. A.,** Solutions for charged particle beams, 17: 33137
**SZCZEPANIAK, V.,** Selective ion change. II., 17: 32195 (KFK-tr-130)
**SZEKERES, P.,** Spaces conformal to a class of spaces in general relativity, 17: 32787
**SZYMANOWSKI, H. W.,** Design of superconducting magnet, 17: 32224

## T

**TACONIS, K. W.,** Melting curve of He-4, 17: 32780
**TAFT, W. C.,** Radiometer for plasma afterglow study, 17: 33217
**TAITS, M. Yu.,** Comparative characteristics of effect of fractionated total irradiation by $\gamma$ and x rays, 17: 31979
**TAKEDA, Shigeru,** Angular distributions of $\alpha$ particles from $Li^6$-induced reactions, 17: 33088
**TAKEI, W. J.,** Magnetic structures in the MnSb–CrSb system, 17: 32622
**TAKETANI, Kiyoaki,** Oxidation rate of intentionally punctured dummy fuel element, 17: 32527
**T'AN, Chio-cheng,** Radiation effects on chromosomal rearrangements in spermatogenesis, 17: 31950
**TANG, Homer H.,** Computation curves for axi-symmetric base pressure analysis, 17: 32730 (TID-19116)
**TANG, Ming-dou,** Low-input-impedance current integrator, 17: 32356
**TANG, Syao-wei,** Measurement of Panofsky ratio by coincidences, 17: 32947
**TANG, Y. C.,** Scattering of He-3 by $\alpha$ particles, 17: 32993 (BNL-6955)
**TANI, Akira,** Determination of O by 14-Mev neutron activation analysis, 17: 32022
**TANI, S.,** Nonadiabaticity in potential scattering, 17: 32967
**TAO, L. N.,** Heat transfer in circular tubes, 17: 32261
**TAPPER, D. N.,** Effect of dietary K and Na on Cs-137 retention in rats, 17: 31836
**TARASENKO, N. D.,** Action of $\gamma$ rays, fast neutrons, and ethyleniminе on potato seeds, 17: 31938
**TATSUMOTO, M.,** Lead in Atlantic and Mediterranean waters, 17: 32274
**TAVERNIER, J.,** Solutions of the stationary Boltzmann equation, 17: 32766
**TAYLOR, C. E.,** Reducing impurity resistivity of Na, 17: 32843
**TAYLOR, J. B.,** Magnetohydrodynamics of rotating fluid, 17: 32874

**TAYLOR, P. G.**, Beryllia ceramics, 17: 32491
**TAYLOR, R. L.**, Kramers' and line radiation from $N_2$ and air shocks, 17: 32705 (BSD-TDR-63-102)
**TE-HOU, Rhen**, Separation of rare-earth elements by electrophoresis, 17: 32196 (UCRL-Trans-973)
**TEODORESCU, I.**, Choice of parameters of linear electron accelerator, 17: 33135
**TEREKHOVA, V. F.**, Rare earth alloys, 17: 32648
**TEREPKA, A. Raymond**, Comparison of natural inulin with its radioactive derivatives, 17: 31920
**TEXTORIS, A.**, Kramers' and line radiation from $N_2$ and air shocks, 17: 32705 (BSD-TDR-63-102)
**THODOS, George**, Viscosity of gaseous and liquid H, 17: 32066
**THOMANN, Hans-Joachim**, Photometric determination of Ce, 17: 32021
**THOMAS, D. A.**, Substructure and mechanical properties of refractory metals, 17: 32565 (ASD-TR-61-181(Pt.III))
**THOMAS, I. D.**, Hanford Pu fuel development laboratory, 17: 32537 (HW-SA-2904)
**THOMAS, R.**, Measuring energy of $\alpha$ beams from 5 to 30 Mev, 17: 32772
**THOMPSON, S. G.**, Kinetic energy and fine structure in spontaneous fission of Cf-252, 17: 32995 (CONF-46-44)
**THORN, R.**, Electronic equipment for Cherenkov detector, 17: 32438
**THORNE, W. L.**, Surge suppressors for PRTR process tube meters, 17: 33368 (HW-70711(Rev.))
**THORSON, Walter R.**, High-energy scattering of normal He atoms, 17: 32823
**THOULESS, D. J.**, Single particle strengths in nuclei, 17: 33049
**THUEMMLER, F.**, Less-known U compounds as nuclear fuels, 17: 33249
**TIEN, T. Y.**, Grain growth of $Ca_{0.15}Zr_{0.85}O_{1.85}$, 17: 32135
**TILBURY, R. S.**, Cadmium-115m,g formed in proton fission of U, 17: 33024
**TILLEY, George P.**, Trichloroacetates of La, Nd, and Dy, 17: 32069
**TIMM, H.**, Hermetical sealing of standard Al irradiation capsules, 17: 32548
**TIMMERMAN, L.**, Catalysis by irradiation in presence of non-metallic solids, 17: 32178
**TIMOFEEVA, N. I.**, Polymorphism of rare earth oxides, 17: 32058
**TIMORES, M. M.**, Abundances of isotopes synthesized by fast-neutron capture, 17: 32869
**TISSI, Carlo**, Welding of reactor for electrothermal nuclear plant, 17: 33260
**TITENKOV, A. F.**, Nuclear particle spectrum at 3260 m altitude, 17: 32892
**TOBIAS, R. Stuart**, Structure of polyanions of transition metals in aqueous solution, 17: 32123
**TODD, H.**, Materials for ion propulsion, 17: 32498
**TOKAREVSKII, V. V.**, Elastic scattering of deuterons on Cr and Zn isotopes, 17: 33071
**TOLGYESSY, J.**, Absorption of $\beta$ radiation for determination of U and Th, 17: 32014
**TOLKACHEVA, E. N.**, Action of protective substances in irradiation of tissues, 17: 31939
**TOLMIE, R. W.**, Winter rail-lubricant study, 17: 32326
**TOMAS, P.**, Yields of D-D neutrons from different targets, 17: 32768
**TOMBRELLO, T. A.**, Direct-capture model for $He^3(\alpha,\gamma)Be^7$ and $T(\alpha,\gamma)Li^7$ reactions, 17: 33104
**TOMKUS, J. (I. S. Tomkus)**, Studies of $\alpha$ radioactivity in atmosphere, 17: 32888
**TOMS, Ronald S. H.**, Mission capabilities of electric propulsion, 17: 32223
**TOSI, Mario**, Cohesive energy of the alkali halide crystals, 17: 32084
**TRAPP, H. D.**, Application of NMR to transition metals, 17: 32569 (CONF-54-1)
**TRAUGER, D. B.**, Clad fuel development, 17: 33323 (ORNL-3445(p.199-217))
**TRAUGER, D. B.**, Fueled-graphite systems, 17: 33322 (ORNL-3445(p.138-98))
**TRAUGER, D. B.**, Irradiation testing of GCR components and materials, 17: 33320 (ORNL-3445(p.63-108))
**TREFILOV, G. P.**, Nucleic metabolism in organs and blood after whole-body irradiation, 17: 31955
**TRETYAKOVA, M. I.**, Ionization-momentum relation for particles in relativistic region, 17: 32453
**TREVINO, S. F.**, Polarization in neutron-deuteron elastic scattering, 17: 32935
**TRIBUKAIT, B.**, Effect of x rays and botulinum toxin on survival of mice, 17: 31901
**TRIMBLE, G. D.**, Neutron thermalization in ZrH, 17: 32974 (GA-4328)
**TRIULZI, C.**, Beta radioactivity of plankton in Adriatic and Ligurian seas, 17: 31845
**TROJAN, O. A. D.**, Gamma-active fallout near Toronto, 1961–1962, 17: 32297
**TROKHOVA, V. F.**, Properties of Mg–Th–Mn system, 17: 32595
**TROST, Adolf**, Device for measuring intensity of radiation, 17: 32465
**TROUVE, J.**, Shaping semi-metallic nuclear fuels, 17: 33278
**TRUMPFHELLER, Rudolf**, Welding seam testing by radiation sources, 17: 32307
**TRUSOVA, N. E.**, Spermatogenesis in dogs in chronic Sr-90 injury, 17: 31929
**TSAO, C. H.**, Interactions of heavy nuclei with energy >$10^{12}$ev/nucleon, 17: 32893
**TSEITLIN, P. I.**, Study of DNA radiation damage by thermal strand separation. II., 16: 31922
**TSEVELEVA, I. A.**, Radiation effects on nucleotides in rabbits, 17: 31932
**TSUBOI, Masamichi**, Normal vibrations of glycine and deuterated glycine molecules, 17: 32146
**TSUDA, Satoru**, Radiolysis of ferrous sulfate solutions. I., 17: 32162
**TSUDA, Satoru**, Radiolysis of ferrous sulfate solutions. II., 17: 32163
**TSUPKO-SITNIKOV, V. M.**, Formation of mesic He in mixture of He and H, 17: 33080
**TSVETKOV, O. S.**, Neutron yield from materials subjected to irradiation with $\alpha$ particles, 17: 33017
**TSVETKOV, O. S.**, Neutron yield from $(\alpha,n)$ reaction on Be, B, C, O, F, Na, Mg, Al, and Si, 17: 33018
**TUAN, Duong-hoang**, Isotope shifts in the resonance line of the arc spectrum of Ba, 17: 33062
**TUCKER, T. C.**, Separation of multicomponent mixtures having small separation factors, 17: 32468 (TID-18966)
**TUDOR, J. J.**, Reactor moderator structure, 17: 33300
**TUITE, G.**, High melting-point glasses containing $UO_2$, 17: 32506
**TUMANYAN, V. A.**, Compton effect on relativistic electrons, 17: 32960
**TUNNICLIFFE, P. R.**, Electronics, 17: 32726 (PR-P-67(p.44-68))
**TURK, M.**, Yields of D-D neutrons from different targets, 17: 32768
**TURVER, K. E.**, Distribution of energy in extensive air showers, 17: 32890
**TVERBERG, J. H.**, Welds of Nb-containing Zr alloys, 17: 32496
**TYLER, S. J.**, Creep cavitation in Magnox A12, 17: 32613
**TYUKOV, D. M.**, Bioelectric activity of uv-irradiated rabbit brain, 17: 31933
**TZCHEUTSCHLER, Wolfgang**, Electron microscopy of irradiated sintered pellets, 17: 32670 (ZFK-WF-21)

## U

**UCCELLI, F.**, Linear theory of accelerators. II., 17: 33117 (LNF-63/18)
**UEGAKI, Kazuo**, Sensitivity of G-I tract against radioactivity, 17: 31896
**UELTZ, Herbert F. G.**, Extraction of Ti, Zr, and Hf, 17: 32514
**ULLAH, Nazakat**, Theory of electron emission widths, 17: 32704 (BNL-6916)
**URRAY, Wm. D.**, Quantitative measurement of small amounts of He, 17: 31987 (AAEC/Trans-14)
**USACHEV, L. N.**, Fission threshold from (d,pf) and $(\gamma,f)$ reactions, 17: 33082
**USTRAVSHIKOVA, K. A.**, Surface properties of alpha U. I., 17: 32602

## V

**VACEK, K.**, Luminescence of pure and doped AgCl crystals, 17: 32161
**VAGER, Z.**, Measurements of gyromagnetic ratios, 17: 32771
**VALAT**, Generation of pseudo-random gating impulse, 17: 32344 (AEC-tr-5901)
**VALE, R. L.**, Radiation-induced vulcanization of hydrocarbon polymers. II., 17: 32167
**VAL'KOV, V. D.**, Change in rate of electrodic reactions under irradiation, 17: 32171
**VALTER, A. K.**, Elastic scattering of deuterons on Cr and Zn isotopes, 17: 33071

**VAN ABKOUDE, E. R.,** Artificial Be-7 in lower stratosphere, 17: 32759
**VAN ALLEN, J. A.,** Intensities of geomagnetically trapped electrons from high-altitude nuclear burst, 17: 32279
**VAN BLADEL, J.,** Proton linear accelerators for energies up to 300 Mev, 17: 33113 (CONF-125-3)
**VAN DER WAERDEN, B. L.,** Wave equation of electron in general relativity theory, 17: 32735 (UCRL-Trans-981)
**VAN GENDEREN, W.,** Hot cathode cyclotron ion source without filament, 17: 33133
**VAN HEARDON, I. J.,** Lifetimes of levels in Ne-21, 17: 33098
**VAN OSTENBURG, D. O.,** Application of NMR to transition metals, 17: 32569 (CONF-54-1)
**VAN RAALTE, D.,** Dissociation of formate esters by electron impact, 17: 32160
**VAN WAMBEKE, L.,** Absolute age of uraniferous minerals of Katanga and Northern Rhodesia, 17: 32265
**VAN WAMBEKE, L.,** Comparative study of ampangabeites and samarskites, 17: 32270
**VARGAFTIK, N. B.,** Heat conductivity of $D_2O$ in gas phase, 17: 32076
**VARTANOVA, L. I.,** Deposition of Cs and Rb from $CO_2$ onto materials, 17: 32061
**VASARU, Gh.,** Separation of stable isotopes. I., 17: 32471
**VASARU, Gheorghe,** Operation of diffusion-condensation chamber, 17: 32450
**VEKSLER, I. G.,** Effects of marrow transplantation on survival of rats, 17: 31971
**VELAN, A. K.,** Design, production and testing of nuclear valves for liquid coolant reactors, 17: 32227
**VELCULESCU, V.-G. A.,** Zeeman levels in alkali metal atoms. II., 17: 32091
**VELIKHOV, E. P.,** Problem of plasma rotation, 17: 33163
**VEL'TISHCHEVA, N. S.,** Atmospheric contamination over Atlantic Ocean in 1961, 17: 31844
**VENEVTSEV, Yu. N.,** Resonance $\gamma$ absorption in Ba, Sr, and Ca stannites, 17: 32107
**VENIKOV, N. I.,** Effect of parameters of cyclotron on accelerated ion bundle, 17: 33124
**VENKATESAN, K.,** Symmetries shared by strong and weak interactions, 17: 32936
**VENTERS, Lydia,** Dependence of gas diffusion coefficient on the mixing ratio, 17: 32052 (AEC-tr-5938)
**VENTERS, Lydia,** Fluorides of Xe and Rn, 17: 32051 (AEC-tr-5920)
**VERA PALOMINO, J.,** Determination of U extracted with methyl isobutyl ketone–TBP, 17: 32001
**VERA PALOMINO, J.,** Spectrophotometric determination of rare earth elements. I., 17: 32002
**VERBA, J. W.,** Continuous rotation scattering chamber, 17: 32393
**VERBOVEN, E.,** Quantum statistical equilibrium for simple model. II., 17: 33231
**VERHAAR, B. J.,** Structure of nuclear rotation bands, 17: 33046
**VERMA, S. D.,** Total absorption spectrometer for Bev range, 17: 32439
**VERNON, P. B.,** Monitoring, decontamination, and bio-assay of Pu-contaminated injury, 17: 31962 (DPSPU-63-30-5)
**VERRI, G.,** Production of electron pairs in thick converters, 17: 32713 (LNF-63/27)
**VESTINE, E. H.,** Magnetic field of earth and planets, 17: 32879
**VIBRANS, G. E.,** Surface temperature of solid under electron bombardment, 17: 32821
**VICHNEVETSKY, R.,** Three-dimensional simulation of nuclear reactors, 17: 33268
**VICTOR, Andrew C.,** Thermodynamic properties of MgO and BeO, 17: 32086
**VIGILEVA, E. S.,** Lanthanum tellurides, 17: 32121
**VIGNON, A.,** Generation of pseudo-random gating impulse, 17: 32344 (AEC-tr-5901)
**VIJAYKAR, S. V.,** Research on U mineral beneficiation. I., 17: 32184
**VILLANI, S.,** Competitivity, 17: 33334
**VINCENT, C. H.,** Precision auxiliary bias unit, 17: 32355
**VINCENT, C. H.,** Speed of response and amplitude of linear ratemeter, 17: 32434
**VINCENT-GEISSE, J.,** Integration of dispersion equations, 17: 33229
**VINER, Harry Sydney Gordon,** Improvements in remote-operating tools, 17: 32231
**VINER, Harry Sydney Gordon,** Improvements in remote-operating tools, 17: 32232
**VINER, Harry Sydney Gordon,** Improvements in remote-operating tools, 17: 32233
**VINER, Harry Sydney Gordon,** Improvements in remote-operating tools, 17: 32234
**VINTAN, I.,** Choice of parameters of linear electron accelerator, 17: 33135
**VIOLET, C. E.,** Electric quadrupole moment of Te-125, 17: 33007 (UCRL-7297)
**VIRYASOV, N. M.,** Production of hyperons ($\Xi^-$) by mesons ($\pi^-$), 17: 32945
**VISHKAREV, A. F.,** Influence of rare earth metals on fused Fe, 17: 32598
**VISHNEVSKII (VISHNEVSKIY), A. A.,** Injuries from atomic bomb explosions, 17: 32295 (JPRS-20511)
**VISKOV, A. S.,** Resonance $\gamma$ absorption in Ba, Sr, and Ca stannites, 17: 32107
**VLCEK, B.,** Rapid determination of radiation by sorbe-mulsion method, 17: 32013
**VODOPICK, Helen A.,** Sulfur-35 studies in man, 17: 31903
**VOHRA, K. G.,** Active particles in fallout from weapon tests, 17: 32283 (AEET/AM/34)
**VOIGT, Adolf F.,** Activation analysis for Na in Na–W bronzes, 17: 31994
**VOITENKO, A. E.,** Production of shock waves in electric discharges, 17: 32801
**VOLODKO, A. G.,** Emission of Li-8 in disintegration of Ag and Br by protons, 17: 33081
**VOLOSHCHUK, A. I.,** Uranium-based cermet alloys, 17: 32657
**VON DER DECKEN, C. B.,** Diffusion of fission products through graphite, 17: 33273
**VON DER DECKEN, C. B.,** Release of fission products from UC–ZrC fuel inserts, 17: 33272
**VONDY, D. R.,** Nuclide chain equations for digital machine calculations, 17: 33244 (ORNL-TM-361(Add.))
**VON HALLE, Edward,** Thermal diffusion columns separating Xe isotopes, 17: 32469
**VON JASKOWSKY, Woldemar,** Plasma pinch as gas accelerator, 17: 33203
**VOSKRESENSKAYA, N. K.,** Reactions of $CeO_2$, $Nd_2O_3$, and $Sm_2O_3$ with molten fluorides, 17: 32111
**VOZZELLA, P. A.,** Thermal decomposition of UN, 17: 32032 (CNLM-5066)
**VREELAND, T., Jr.,** Prog. rpt. on dislocation mobility and density of metallic crystals, 7/63, 17: 32575 (TID-19181)

## W

**WACHTER, J. W.,** Nuclear Safety Handbook of Y-12 plant, 17: 32293 (Y-1272)
**WACHTMAN, J. B., Jr.,** Symmetry splitting of equivalent sites in oxide crystals, 17: 32607
**WADDINGTON, C. J.,** Recent studies of solar cosmic rays, 17: 32885
**WADE, G. E.,** Fission product confinement for NPR, 17: 33363 (HW-SA-2891(Rev.))
**WAKABAYASHI, Jiro,** Nuclear reactor spatial kinetics, 17: 33257
**WALKER, G.,** Slow component of luminous emission in organic scintillators, 17: 32426
**WALLACE, W. E.,** Laves phases containing lanthanides combined with Fe and Co, 17: 32819
**WALLERSTEIN, G.,** Metal abundances in subgiant $\zeta$ Herculis, 17: 32852
**WALLWORK, G. R.,** Diffusion of O in Hf, 17: 32601
**WALTER, H.,** Properties of CsBr(Tl) and RbI(Tl) crystals, 17: 32444
**WALTER, R. L.,** Scattering of polarized neutrons by $\alpha$ particles, 17: 32932
**WANG, Chih H.,** Coordinated design of radioisotope laboratories, 17: 31805
**WANG, Chuan-pen,** Secondary D and T capture reactions, 17: 33075
**WANG, H. S. C.,** Nonlinear stationary waves in relativistic plasmas, 17: 33170
**WANG, H. S. C.,** Nonlinear transverse waves in plasmas, 17: 33199
**WANG, Kang-ch'ang,** Production of hyperons ($\Xi^-$) by mesons ($\pi^-$), 17: 32945
**WANG, Shou-min,** Time resolution characteristics of photomultiplier, 17: 32371
**WANG, To-cheng,** Problems of photo-multiplier tubes, 17: 82451
**WANG, Tsu-tseng,** Production of hyperons ($\Xi^-$) by mesons ($\pi^-$), 17: 32945
**WANKLYN, J. N.,** Corrosion of Zr and its alloys, 17: 32520

**VAPSTRA, A. H.**, Gamma ray transitions in Cl-35, 17: 33059
**VARD, C. B.**, Nanosecond pulse-height discriminator, 17: 32436
**VARD, D. L.**, Three-fluid nonequilibrium plasma accelerators. II., 17: 33210
**VARING, J. L.**, Polymorphism of $ABO_3$-type rare earth borate solid solutions, 17: 32124
**VARNER, Philip Cloudsley**, Improvements in nuclear reactors, 17: 33291
**VARREN, I. H.**, Uranium compounds as thermoelectric materials, 17: 32587
**VASSERMAN, R. H.**, Effect of dietary K and Na on Cs-137 retention in rats, 17: 31836
**VATERS, T. C.**, Prestressed concrete pressure vessels, 17: 33254
**VATKINS, E. Jr.**, Current applications of fiber optics to fluoroscopy, 17: 31822
**VATSON, D. D.**, Note on angular distribution analysis, 17: 33033
**VATSON, G. M.**, Fueled-graphite systems, 17: 33322 (ORNL-3445(p.138-98))
**VATSON, G. M.**, Moderator materials, 17: 33324 (ORNL-3445(p.218-50))
**VATT, D. E.**, Determination of Pu-239, Pu-238 and Pu-236, 17: 32992 (AWRE-O-59/63)
**VEAVER, Charles L.**, Regulating byproduct, source, and special nuclear material, 17: 32316
**VEBB, F. J.**, Cold neutron sources, 17: 32980
**VEBB, William A.**, Digital computer program for thermodynamic properties of $D_2O$, 17: 32038 (CVNA-129)
**VEBSTER, D. S.**, Calcination of waste in molten S, 17: 33402
**VEBSTER, R. J.**, Interpretation of recoil proton spectra, 17: 32420
**VECKESSER, A.**, Operating experience of Kahl Nuclear Power Station, 17: 33338
**VEGE, E.**, Influence of graphitization-time and -temperature on ash content of electrographite, 17: 32655
**VEIDENBAUM, B.**, Failures of $UO_2$ swaged fuel rod, 17: 32664 (GEAP-4197)
**VEINMAN, J. A.**, Observation of Be-8 in ground state, 17: 33054
**VEINSTEIN, M. S.**, Fallout protection in structures, 17: 31804 (WT-1462)
**VEISMAN, J.**, Prog. rpt. on miniature neutron detector, 1–3/63, 17: 32404 (WCAP-2274)
**VEISS, G.**, Device for generating high-density plasma, 17: 33220
**VEISSBLUTH, M.**, EPR of uv-irradiated amino acids, polypeptides, and proteins, 17: 31850 (AD-294 395)
**VEISSMANN, S.**, Substructure and mechanical properties of refractory metals, 17: 32565 (ASD-TR-61-181(Pt.III))
**VEITKAMP, C.**, Photofraction of NaI(Tl) scintillation detector, 17: 32415
**VEITKAMP, C.**, Photofractions of cylindrical NaI(Tl) scintillation detectors, 17: 32416
**VEITZENHILLER, Franz**, Selective ion change. II., 17: 32195 (FKF-tr-130)
**VEITZNER, Harold**, Plasma oscillations and Landau damping, 17: 33171
**VELFARE, F. G.**, Nuclear Safety Handbook of Y-12 plant, 17: 32293 (Y-1272)
**VELLER, W. W.**, Heat capacities of sesquioxides of Sc and Ce, 17: 32031 (BM-RI-6245)
**VENTWORTH, R. A.**, Thyroidal deposition of radioiodine from milk, 17: 31849
**VENZEL, Albert W.**, Purification of Pu sulfate tetrahydrate, 17: 32055
**VENZEL, P.**, Investigations of U–Pu cycles. II., 17: 33364
**VENZEL, William A.**, Bevatron external proton beam, 17: 33122 (UCRL-10868)
**VEREZAK, G. N.**, Radiation-induced graft polymerization of styrene in wood, 17: 31807
**VERNER, Horst Robert**, Kinetics of $\gamma$ radiolysis of chloroform, 17: 32155 (TID-19203)
**VERNER, Lothar**, Decay of Tm-168, 17: 33008 (ZFK-PHA-8)
**VERNER, R. D.**, Cobalt resonance capture integral, 17: 33025
**VEST, H. I., Jr.**, Electrons trapped in the earth's magnetic field following nuclear bursts, 17: 32845 (UCRL-7309(Rev.I))
**VESTIN, R.**, Paramagnetism of Mn dissolved in Cu–Al and Cu–Ge alloys, 17: 32561 (AE-111)
**VESTMEYER, H.**, Moisture measurements by neutrons, 17: 32017
**VETZEL, Klaus**, Enrichment of D by isotope exchange, 17: 32473
**WHARTON, Leonard**, Geometry of $Li_2O$ by electric deflection, 17: 32030 (AROD-006.9)
**WHATLEY, M. E.**, Pot-calcination process, 17: 33403
**WHEATLEY, G. H.**, Silicon p-n junction radiation detectors, 17: 32458
**WHEELER, E. L.**, Prog. rpt. on Hg-lubricated journal bearings, 10–12/62, 17: 32249 (SY-5455-R)
**WHEELER, M. J.**, Physical properties of UC, 17: 32636
**WHIPPLE, G. Hoyt**, Comparative study of radiation regulations, 17: 32317
**WHISMAN, Marvin L.**, Purification of radioactive organic compounds, 17: 32140
**WHITE, J.**, Systems of UC, $UC_2$, and UN with transition metals, 17: 32637
**WHITE, J. C.**, Preparation of pure LiF, 17: 32193 (ORNL-TM-637)
**WHITE, P. H.**, Interpretation of recoil proton spectra, 17: 32420
**WHITLEY, J. E.**, Neutron activation determination of Si, Zn, and Mg in GaAs, 17: 32004
**WHITNEY, Charles A.**, Structure of shock front in atomic H. I., 17: 32744
**WHITTAKER, J. K.**, Nanosecond neutron time-of-flight system, 17: 33032
**WHITTAKER, V. N.**, Creep cavitation in Magnox A12, 17: 32613
**WIGGIN, Edwin A.**, Reducing shipper-receiver differences, 17: 32315
**WIKHAMMER, G. A.**, Steam/water mixtures flowing in heated annulus, 17: 32260
**WILDERMUTH, K.**, Scattering of He-3 by $\alpha$ particles, 17: 32993 (BNL-6955)
**WILKINS, N. J. M.**, Corrosion of Zr and its alloys, 17: 32520
**WILLARD, H. B.**, Neutron cross section program, 2/15–8/1/63, 17: 33005 (ORNL-TM-636)
**WILLIAMS, C. M.**, Effects of neutron irradiation on magnetic properties of alloys, 17: 32692
**WILLIAMS, Ffrancon**, Radiation chemistry of hydrocarbons, 17: 32170
**WILLIAMS, M. M. R.**, Energy-dependent Milne problem with simple scattering kernel, 17: 32969 (BNL-6949)
**WILLIAMS, N. L.**, Design of $D_2O$ moderated and cooled nuclear power plant, 17: 33360
**WILLIAMS, N. L.**, 1800 Mwe nuclear plant: design and cost, 17: 33332
**WILLS, R. D.**, Distribution of energy in extensive air showers, 17: 32890
**WILSON, A. D.**, Determination of As by oxygen flask technique, 17: 32003
**WILSON, C. R.**, Analysis and evaluation of fallout radioactivity, 17: 32288 (NSEC-91)
**WILSON, C. W.**, Extension of APT to obtain centroid and inertia information, 17: 32477 (Y-1420)
**WILSON, Shirley M.**, Radioprotection by pressor amidines, 17: 31948
**WILSON, T. H.**, Prog. rpt. on waste disposal, 6/1/60–9/1/60, 17: 32045 (TID-19183)
**WILSON, T. H.**, Prog. rpt. on waste disposal, 5/15–12/31/59, 17: 32046 (TID-19185)
**WINDISCH, St.**, Niobium–Ta alloys for impregnation, 17: 32495
**WINKWORTH, R.**, Control system for neutron spectrometer, 17: 32433
**WINSCHE, W. E.**, Calcination of waste in molten S, 17: 33402
**WINSLOW, Fitz R.**, Fuel element for a reactor, 17: 32559
**WISWALL, R. H.**, Chemistry and chemical engineering, 17: 31795 (BNL-782 (p.18-43))
**WITKOWICZ, J.**, Biological effect and prophylaxis of microwave irradiation, 17: 31911
**WITT, F. J.**, Experimental stress analysis of nuclear reactor pressure vessel, 17: 33252
**WOESSNER, D. E.**, Nuclear transfer and anisotropic motional spin phenomena. IV., 17: 32134
**WOLF, H.**, Mechanical engineering in suspension reactor project, 17: 33377
**WOLFF, A. K.**, Prog. rpt. on $\beta$ treatment of U, 8–11/61, 17: 32539 (NMI-2805)
**WOLLENBERG, Harold A.**, Terrestrial gamma radioactivity, 17: 32264 (UCRL-10636)
**WOLTER, W.**, Interactions of heavy nuclei with energy $>10^{12}$ev/nucleon, 17: 32893
**WOMACK, James R.**, Electric space cruiser, 17: 32221
**WOOD, Gwendolyn B.**, Embrittlement of high-strength steels. I., 17: 32521
**WOOD, Gwendolyn B.**, Embrittlement of high-strength steels. II., 17: 32522
**WOOD, J. S.**, Crystal and molecular structure of bis(dipivaloylmethanido)-zinc(II), 17: 32040 (NYO-10552)
**WOOD, R. S.**, Prog. rpt. on dislocation mobility and density of metallic crystals, 7/63, 17: 32575 (TID-19181)

**WOOD, Van E.**, Hyperfine interaction in atomic Li, 17: 33102
**WOODCOCK, Alfred H.**, Deuterium content of raindrops, 17: 32272
**WOOTEN, F.**, Electric quadrupole moment of Te-125, 17: 33007 (UCRL-7297)
**WOOTON, P.**, Dosage to important sites in radiation therapy, 17: 31872
**WORK, Ralph O.**, Bayonet type coupling, 17: 32240
**WORLOCK, R.**, Materials for ion propulsion, 17: 32498
**WORSHAM, H. J., Jr.**, Prototype nuclear-fueled thermionic converter test, 17: 32836
**WRAY, J. A.**, Preparation of cellulose graft copolymers. I., 17: 31809
**WRIGHT, B. T.**, Design of 720-Mev proton FFAG accelerator, 17: 33112 (CONF-125-2)
**WRIGHT, R. E.**, High-current linear induction accelerator for electrons, 17: 33119 (UCRL-7408)
**WULFF, J.**, Niobium–Th eutectic alloy as superconductor, 17: 32650
**WULLAERT, Richard A.**, Radiation stability of UN, 17: 32660 (BMI-1638)
**WURDACK, G. Th.**, Absorption of $NaI^{131}$ through rat skin after x irradiation, 17: 31957
**WYATT, A. G.**, Influence of steam cycle performance on nuclear power costs, 17: 33356

## Y

**YAFFE, L.**, Cadmium-115m,g formed in proton fission of U, 17: 33024
**YAFFE, L.**, Neutron-deficient isotopes of La, 17: 33023
**YAGODA, Herman**, Interaction of cosmic and solar flare radiations with Martian atmosphere, 17: 32881
**YAKUSHEV, A. M.**, Solubility of H in liquid Fe, 17: 32597
**YAMADA, Yukio**, Studies on fallout particles. III., 17: 32302
**YAMAMOTO, Hozumu**, Sensitivities of Fuji badge film to $\beta$ rays, 17: 32414
**YAMAMOTO, Kakuji**, Radiation effects on charged glass tubes, 17: 32687
**YANG, John Y.**, Tritium $\beta$-decay induced reactions in polystyrene fluff, 17: 32152 (CONF-14-21)
**YANG, Tsi-lan**, Operation of neutron diffractometers, 17: 32368
**YAN'KOV, G. B.**, Mass-flow function of Ni-62, Se-80, Cd-114, and Sn-118, 17: 33027
**YAREMBASH, E. I.**, Lanthanum tellurides, 17: 32121
**YARMONENKO, S. P.**, Cytological analysis of action of high-energy protons. II., 17: 31942
**YARMONENKO, S. P.**, Effect of chemical antiradiation preparations, 17: 31966
**YASUDA, H.**, Preparation of cellulose graft copolymers. I., 17: 31809
**YATES, M. J. L.**, Photopeaks measured with NaI crystals, 17: 32427
**YAVOISKII, U. I.**, Influence of rare earth metals on fused Fe, 17: 32598
**YAVOISKII, V. I.**, Solubility of H in liquid Fe, 17: 32597
**YELAGIN, Yu. P.**, Optical model for cross sections of radiative capture, 17: 33048
**YING, Hu Yu**, Calculations of a boundary on dielectric plane, 17: 32781
**YONEMURA, Toshio**, Strontium-90 in bone of animals in Japan, 17: 32300
**YORK, C. M.**, Nanosecond pulse-height discriminator, 17: 32436
**YOSHITSUGU, Mishima**, Effect of metal addition upon 2S, 52S and 61S Al, 17: 32608
**YOUNG, D. E.**, Proton linear accelerators for energies up to 300 Mev, 17: 33113 (CONF-125-3)
**YOUNG, F. C.**, Charged-particle detector for magnetic analyzers, 17: 32428
**YOUNG, G. A.**, Slide-dam construction employing nuclear explosives, 17: 32209 (SC-4781(RR))
**YOUNG, J. C.**, Neutron thermalization in ZrH, 17: 32974 (GA-4328)
**YOUNG, R. G.**, PL condenser evaluation report, 17: 33303 (CEND-139)
**YOUNGBLOOD, B. J.**, Nuclear Safety Handbook of Y-12 plant, 17: 32293 (Y-1272)
**YUNUS, M.**, Recrystallization of $UO_2$ at high temperature, 17: 32126
**YUST, C. S.**, Dislocation movement in sintering of $CaF_2$, 17: 32037 (CONF-50-14)
**YUST, C. S.**, Material transport during sintering of fluorite structure materials, 17: 32535 (CONF-50-15)
**YUZVUK, N. N.**, Deposition of Cs and Rb from $CO_2$ onto materials, 17: 32061

## Z

**ZACHARIASEN, W. H.**, Secondary extinction correction, 17: 32829
**ZACHAROV, B.**, Spark chamber with high detection efficiency, 17: 32417
**ZAIKA, M. I.**, Reduced nuclear level widths from nuclear reactions, 17: 33066
**ZAIMIDOROGA, O. A.**, Formation of mesic He in mixture of He and H, 17: 33080
**ZAITSEVA, L. S.**, Heat conductivity of $D_2O$ in gas phase, 17: 32076
**ZAKHARCHENKO, M. A.**, Reciprocal ternary system formed by bromides and nitrates of Na and Ba, 17: 32112
**ZAKHARCHENKO, M. A.**, Ternary system containing chlorides of Li, Na, and Ba, 17: 32120
**ZAMOCHNICK, S. B.**, Direct determination of some alkali metal ions, 17: 31998
**ZATSEPINA, G. N.**, Distributions of photoneutrons from Bi, Au, and Ta, 17: 33074
**ZAUBERIS, D. D.**, Neutron studies of nonstoichiometric metal hydrides, 17: 32580
**ZAVATTARELLI, R.**, Critical heat flux data for flow of steam–water mixtures, 17: 32244 (EURAEC-637)
**ZAVATTARELLI, R.**, Critical heat flux data for flow of steam–water mixtures, 17: 32245 (EURAEC-671)
**ZAVOISKII, V. K.**, Kinetics of homogeneous BWR, 17: 33246
**ZELENSKII, V. F.**, Impregnation of graphite with Si in vacuum, 17: 32554
**ZELENSKII, V. F.**, Magnesium cermets and Mg–Be alloys, 17: 32553
**ZELENSKII, V. F.**, Uranium-based cermet alloys, 17: 32657
**ZETTWOOG, P.**, MHD conversion in inhomogeneous flow, 17: 33219
**ZHARKOV, G. F.**, Hollow superconductors in magnetic field, 17: 32809
**ZHDANOV, G. B.**, Ionization-momentum relation for particles in relativistic region, 17: 32453
**ZHDANOV, S. M.**, Magnesium cermets and Mg–Be alloys, 17: 32553
**ZHIGLINSKII, A. G.**, Isotopic composition after emission spectra of molecules, 17: 32023
**ZHIKHAREV, M. I.**, Composition of vapor phase over nitric acid solutions, 17: 33400
**ZHIRNOV, Yu. P.**, Composition of vapor phase over nitric acid solutions, 17: 33400
**ZHURAKOVSKII, E. A.**, Fine structure of Sc's x-ray absorption K-spectra, 17: 32589
**ZIEMER, Richard W.**, Hall current plasma accelerator, 17: 33205
**ZIMAKOV, P. V.**, Behavior of radioisotopes incorporated in glass blocks, 17: 33404
**ZIMAKOV, P. V.**, Heat release from high-activity solid substances, 17: 33407
**ZIMIN, E. P.**, Effects of magnetic fields on electroconductivity, 17: 32814
**ZIMMERMAN, D.**, Thermoluminescent dosimeter reading system, 17: 32448
**ZIMMERMAN, J. R.**, Nuclear transfer and anisotropic motional spin phenomena. IV., 17: 32134
**ZINN, Walter H.**, Power Reactor Technology, Vol. 6, No. 3, 6/63, 17: 33361
**ZINOVEVA, K. N.**, State diagram of $He^3$–$He^4$ solutions, 17: 32802
**ZITEK, C. B.**, Operating experience at Dresden Nuclear Power Station, 17: 33352
**ZIVANOVIC, B.**, Vibratory compaction of $UO_2$ powder, 17: 32552
**ZNAMIROVSCHI, V.**, Determination of H–D isotope effects, 17: 31989
**ZOTIKOV, E. A.**, Action of bone marrow transfusions in radiation sickness, 17: 31970
**ZUBER, N.**, Prog. rpt. on two-phase flow, 4–6/63, 17: 32246 (GEAP-4251)
**ZUBOVSKII, G. A.**, Blood changes in treatment of capillary hemangioma, 17: 31905
**ZUMWALT, Glen W.**, Computation curves for axi-symmetric base pressure analysis, 17: 32730 (TID-19116)
**ZYABKIN, V. A.**, Neutron yield from materials subjected to irradiation with $\alpha$ particles, 17: 33017
**ZYUZIN, I. K.**, Trace elements in development of radiation pathology, 17: 31928

# SUBJECT INDEX

Main entries in this index are generally specific materials, things, and processes. These are followed by modifiers that describe the properties of, and processes applied to, the main entries. A more complete description of the patterns and style of indexing used is included in the introductions to the subject index cumulations that are issued quarterly.

As an aid to the users of this index, references to report numbers, where appropriate, are included after the abstract number of the citation.

The number preceding the colon is the *NSA* volume number, and the number following is the abstract number in that volume. The designation (R) following the abstract number indicates that the abstract is of a progress report; (P) indicates a patent; and (T) indicates a translation. Abstracts for reports other than progress reports carry no letter designation. Published literature (journal article or book) is identifiable by the absence of a report number.

## A


**ACCELERATORS**
development of electron, worldwide, 17: 32917 (TID-7668(Sect.IX))
magnets for, pole shaping for strong- and weak-focusing, 17: 32791
properties of storage rings, 17: 32914 (TID-7668(Sect.VI))
radiation damping in, classical analysis of, 17: 33127
storage ring development, 17: 33140

**ACETIC ACID**
ionization constant of, deuterium isotope effects on, 17: 32151
solvent additive effects on radioinduced graft polymerization of cotton cellulose and rayon on polystyrene, 17: 31808

**ACETIC ACID, [(CARBOXYMETHYLIMINO)BIS(ETHYLENENITRILO)] TETRA-**
complexes with europium and scandium, formation and stability, 17: 32110

**ACETIC ACID, (ETHYLENEDIAMINE)TETRA-**
analytical use for tetrametric determination of thorium, 17: 31993
solvent properties to lanthanum, for rare earth separation, 17: 32202

**ACETIC ACID, NITRILOTRI-**
electrophoresis processes in, 17: 32196(T) (UCRL-Trans-973)

**ACETIC ACID, TRICHLORO-, RARE EARTH SALTS**
preparation and properties of, 17: 32069

**ACETIC ACID, VINYL ESTER POLYMERS**
radioinduced vulcanization of, effects of *m*-phenyldi- and *N*-phenyl maleimides on, 17: 32167

**ACETONE**
solvent properties in cation-exchange separations, 17: 32092
solvent properties for thorium and uranium, 17: 32194(R) (TID-19068)

**ACETONE, THENOYLTRIFLUORO-**
solvent properties for americium, pH limit on, 17: 31797(R) (BNL-782 (p.51-9))

**ACETYLENE**
helium-3 reactions at 29 Mev, 17: 32153 (JEN-119-DF/I-36)

**ACETYLENE, DIPHENYL-**
luminescence, decay of slow component of, 17: 32426

**ACROLEIN POLYMERS**
radioinduced film formation from, on glass and quartz, 17: 32695

**ACRYLAMIDE**
graft polymerization of, on cellulose, ceric ion, preirradiation, and radiation methods for, 17: 31809
radiation polymerization of solid solution with propionamide, 17: 31796(R) (BNL-782(p.44-50))

**ACTIVATION ANALYSIS**
gamma energies in, tables of, 17: 32709 (IFA/SN/17)
gamma spectra from, display and interpretation of, 17: 32010
method for determination of $10^{-9}$ samples, 17: 32026
methods of, for selective determination of light elements by alpha reactions, 17: 32015
neutron sources for, 17: 32009
principles and uses in industry, 17: 32330
survey, 17: 32008
use in criminology, biology and medicine, nutrition, and industry, survey of, 17: 32011
use in determination of moisture, 17: 32017

**ACTIVITY COEFFICIENTS**
measurement in dilute binary liquid-metal solutions, 17: 32633

**ADRENAL GLANDS**
activity, effects of x radiation and pertussis sensitization, 17: 31910

**ADRENOCORTICOTROPIC HORMONE**
protective effects against radiation injury of gastrointestinal tract, 17: 31896

**ADRIATIC SEA**
plankton beta activity in, May 1961 to Nov. 1962, 17: 31845

**AERIAL SURVEYING**
equipment design for detecting and identifying gamma-emitting elements in, 17: 32462(P)

**AEROSOLS**
determination in test atmospheres, design of chamber for, 17: 32289 (UR-629)
monitoring radioactive, techniques for, 17: 32456

**AGE ESTIMATION**
book: *Radiogenic Argon in Minerals and Rock*, 17: 32278
of Antarctic rocks, review of, 17: 32266
of minerals from rocks of Kasai basement in Congo by strontium–rubidium measurements, 17: 32269
of pegmatite and vein minerals from Rwanda-Urundi, 17: 32268
of uraniferous minerals of Katanga and N. Rhodesia, 17: 32265

**AGING**
effects on behavior, in dogs, 17: 31863(R) (UCD-107(p.74-85))
effects on dominance-submission patterns, in female dogs, 17: 31864(R) (UCD-107(p.86-97))
effects on eyes, in dogs, 17: 31861(R) (UCD-107(p.44-9))
effects on induction of mammary tumors, in dogs, 17: 31860(R) (UCD-107(p.30-43))
effects on physical condition, in dogs, 17: 31859(R) (UCD-107(p.13-29))
pathological conditions associated with, in dogs, 17: 31867(R) (UCD-107(p.129-274))
tissue scarring as factor in, 17: 31827

**AIR**
analysis for radon, engineering drawing of equipment for, 17: 32375
corrosive and structural effects on chromium-molybdenum carbon steel and type 316 stainless steel at 1100 and 1200°F, 17: 32571(R) (MSAR-63-105)

detection of solidified, in cryostats, 17: 32353
electron avalanche growth in, visible discharge in, 17: 32786
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
friction in annulus with roughened inner surface and smooth outer surface, 17: 33326(R) (ORNL-3445(p.298-328))
reactions with punctured dummy fuel element at 450 and 550°C, oxidation rates in, 17: 32527
separation from water, development of centrifugal separators for, 17: 32206(R) (ACNP-63021)
shock waves in, radiation behind, 17: 32705 (BSD-TDR-63-102)

**AIRCRAFT**
research program of Air Force Materials Laboratory, 17: 32513

**ALANINE**
effects on enzymatic activity of irradiated pepsin, 17: 31940

**ALGAE**
concentration of cesium-137 and calcium-45 by, 17: 31830 (TID-19127)
marine, analysis for niobium-95 and zirconium-95, spectrographic, 17: 32005

**ALKALI METAL NITRATES**
decomposition by light ions at 1 to 15 kev, mechanism of, 17: 32169

**ALKALI METALS**
boiling points of, calculation of, 17: 32592
energy levels of, selective populating of Zeeman, 17: 32091

**ALKALINE EARTH OXIDES**
separation of, from bauxite by direct electrolysis and precipitation, economics of, 17: 32065

**ALKENES**
radiation effects on, cosmic, 17: 32693

**ALLOYS**
book: *Electrodeposition of Alloys. Principles and Practice.* Vol. I, 17: 32510
book: *Electrodeposition of Alloys. Principles and Practice.* Vol. II, 17: 32511
preparation and properties of impregnated, 17: 32495
radiation effects on corrosion, mechanical, physical and thermal properties of, 17: 32679

**ALPHA BEAMS**
energy measurements of, using range-energy relation, 17: 32772

**ALPHA DECAY**
correlations in, measurement of alpha-gamma angular, 17: 32446

**ALPHA PARTICLES**
detection and measurement of, engineering drawings of solid-state detector for, 17: 32378
detection of atmospheric, 17: 32888
effects on molecular weight of desoxyribonucleic acid, from injected plutonium-239 in rabbits, 17: 31923
emission in lithium-6 reactions ($Li^6$,α) with carbon-12 and lithium-6, angular distributions for, 17: 33088
interactions with neutrons at 2–24 Mev, polarization asymmetry in elastic, 17: 32932
interactions with helium-3 at 0 to 20 Mev, 17: 32993 (BNL-6955)
reactions (α,d) with lithium-6 at 23.7 and 24.5 Mev, angular distributions from, 17: 33014
reactions (α,d), (α,n), and (α,p) with boron-10 at 4 to 11 Mev, 17: 33105
reactions (α,γ) with helium-3 at 0.42–5.80 Mev, energy dependence of capture cross sections and transition branching ratios in, 17: 33103
reactions (α,γ) with helium-3 and tritium, direct-capture model for, 17: 33104
reactions (α,n) with nuclei, neutron yields from, 17: 33017
reactions (α,n) with nuclei, neutron yields from, 17: 33018
reactions (α,xn) with rubidium isotopes, excitation functions for, 17: 31797(R) (BNL-782(p.51-9))
reactions (α,2α) with carbon-12 and fluorine-19 at 22.5 Mev, angular correlations for, 17: 33097
reactions on germanium isotopes, arsenic isotopes from, 17: 33075
reactions with boron-11 at 6.5–10 Mev, energy spectra of charged particles from, 17: 33107
scattering on carbon-12 and magnesium-24 at 22.5 Mev, magnetic substates population from, 17: 33099
scattering on magnesium-24, oxygen-16, and silicon-28 at 22.5 Mev, differential cross sections for, 17: 33101
stopping of, by complex atoms, 17: 33223(T) (UCRL-Trans-972)

**ALPHA SOURCES**
radioactivity of plutonium, comparison of techniques of determining, 17: 32992 (AWRE-O-59/63)

**ALUMINUM**
alpha reactions (α,n) with, neutron yields from, 17: 33017
alpha reactions (α,n) with, neutron yields from, 17: 33018
determination in coal by nuclear techniques, 17: 31985 (CONF-124-1)
determination of, spectrophotometric, 17: 32028
diffusion of uranium in liquid, 17: 32500
electron emission by, gamma-induced, 17: 32726(R) (PR-P-57(p.44-58))
electronic structure, 17: 32659
flange seal of, vacuum testing of, 17: 33159(R) (ORNL-3472(p.107-18))
gamma scattering from point source in, 17: 32923
ion exchange with cerium, silver, and zinc on Dowex 50W resin, rate of, 17: 32053
nuclear shapes and sizes in, 17: 33073
purification by zone refining, 17: 32502
radiation effects on corrosion, mechanical, physical and thermal properties of, 17: 32679
radiation effects on plastic deformation of, 17: 32684
recrystallization of high-purity, effects of beryllium on, 17: 32611
separation from acid-ether solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from titanium by cation exchange chromatography, 17: 32054
spectra of, infrared, 17: 32739
wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445 (p.199-217))
x-ray yields from electron bombardment of, K, 17: 32789

**ALUMINUM ALLOYS**
coating with cesium and rubidium by deposition from carbon dioxide, 17: 32061
mechanical properties of, alloying effects of hafnium, tantalum, vanadium, and yttrium on, 17: 32608
structure of solidification zones in, effects of zirconium on formation of macro-, 17: 32591
Al–Cr–Zr, oxidation and mechanical properties, 17: 32621
Al–Cu–Mn, paramagnetism and valency in, 17: 32561 (AE-111)
Al–Fe–Zr, oxidation and mechanical properties, 17: 32621
Al–Li, radioinduced tritium production in, 17: 33110(P)
Al–Li, recyrstallization of helium-containing cold-worked and irradiated, 17: 32603
Al–Mg–Zn, effects of polarization on stress corrosion of, 17: 32530
Al–Ni–Zr, oxidation and mechanical properties, 17: 32621
Al–Pu, burnup in PRTR, 17: 32666 (HW-77935)
Al–U, fabrication and microstructure of castings, 17: 32500
Al–U, uranium separation from, 17: 31795(R) (BNL-782(p.18-43))
Al–Zr, test casting in dies and molds, 17: 32591

**ALUMINUM COMPACTS**
$Al–U_3O_8$, reactions in, 17: 32488(R) (TID-19057)
$Al–UO_2$, reactions in, 17: 32488(R) (TID-19057)

**ALUMINUM COMPLEXES**
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068

**ALUMINUM CRYSTALS**
preparation and polishing, 17: 32575(R) (TID-19181)

**ALUMINUM FLUORIDES**
formation of, free energy of, 17: 31795(R) (BNL-782(p.18-43))

**ALUMINUM ISOTOPES Al-26**
energy levels of, low-lying, 17: 33057

**ALUMINUM ISOTOPES Al-27**
deuteron scattering on, differential and total cross sections for splitting in, 17: 33068
gamma scattering by, resonant, 17: 32725(R) (PR-P-57(p.37-43))
proton reactions (p,γ) with, resonance yield curves for, 17: 32998 (CONF-52-3)
proton reactions (p,α) at 1.0–2.5 Mev, excitation functions for, 17: 33045

**ALUMINUM ISOTOPES Al-28**
half life, 17: 31797(R) (BNL-782(p.51-9))

**ALUMINUM NITRATES**

$Al(NO_3)_3$–HF–$HNO_3$, corrosive effects on type 304L stainless steel and zirconium, 17: 32192(R) (DP-839)
**ALUMINUM OXIDE COMPACTS**
$Al_2O_3$–$Gd_2O_3$, fabrication and properties of sintered, 17: 33236(R) (ACNP-63022)
**ALUMINUM OXIDE CRYSTALS**
point defect sites in, internal friction peak from symmetry splitting of equivalent, 17: 32607
**ALUMINUM OXIDES**
additive effects on hardness of zirconia at room temperature, 17: 32484(R) (GEAP-4284)
additive effects on creep, hardening, and strength of uranium alloys, 17: 32657
mechanical flow properties at high temperatures, 17: 32614
preparation of crystals of, by zone melting at 2320 to 3800°K, 17: 32590
radiation effects on thermoluminescent properties of, 17: 32402(R) (TID-19112)
separation of zirconium oxide from, as function of $SO_3$–$ZrO_2$ ratio, 17: 32077
sorptive properties for cesium and strontium, 17: 32045(R) (TID-19184)
$Al_2O_3$–$UO_2$, fabrication, properties, and radiation stability of, 17: 33262
**ALUMINUM SILICATES**
solvent properties of, for uranium dioxide in high-melting glasses, 17: 32506
**AMERICIUM**
analysis for oxygen, activation, 17: 31992
separation by extraction using thenoyltrifluoroacetone, pH limit to, 17: 31797(R) (BNL-782(p.51-9))
**AMERICIUM ISOTOPES**
neutron fission of, average number of fission neutrons in, 17: 33016
**AMERICIUM ISOTOPES Am-243**
determination in presence of curium-244, isotopic dilution-mass spectrometric, 17: 31997
**AMIDE POLYMERS**
radiation effects on properties of, 17: 32181(P)
radiation effects on grafting monomers onto, 17: 32329
radioinduced crosslinking of, 17: 32181(P)
**AMIDINES**
protective effects of, against radiation damage to mice, effects of pharmaceuticals on, 17: 31948
**AMINO ACIDS**
radiation effects on, ultraviolet thermoluminescence and electron paramagnetic resonance of, 17: 31850 (AD-294395)
synthesis of tritium-labeled, and use in histoautoradiography, 17: 31842
**AMMONIA**
content in rabbit blood during radiation sickness, effects of glycocoll and peptone on, 17: 31975
isotopic exchange between liquid, and hydrogen on heterogeneous catalysts, 17: 32078
yield of, in gamma radiolysis of cystine, effects of sodium chloride on, 17: 32158
**AMMONIUM PLUTONIUM(IV) FLUORIDES**
preparation and properties of, 17: 32072
**AMMONIUM URANIUM FLUORIDES**
precipitation from uranyl nitrate solutions by reduction, kinetics of, 17: 32187
preparation and properties of, 17: 32072
**AMPANGABEITES**
chemical properties, comparison with samarskites, 17: 32270
**AMPLIFIERS**
design and characteristics of fast transistorized pulse, 17: 32359
design and performance of transistorized logarithmic, for nuclear instrumentation, 17: 32349
design of d-c, for neutron thermopile or thermocouple, 17: 32339 (RT/EL(63)3))
design of linear, for high counting rates, 17: 32334 (CONF-58-4)
development of high-speed current, 17: 33152(R) (ORNL-3472(p.9-23))
operation of three-phase magnetic, instability and representation of, 17: 32324 (UCRL-10855)
**AMYL ALCOHOL**
solvent properties for elements, 17: 32194(R) (TID-19068)
**ANIMAL CARE**
of dogs, 17: 31858(R) (UCD-107(p.7-12))
**ANIMAL CELLS**
in tissue culture, protective effects of aminoethylisothiuronium and propyl gallate against radiation injuries in, 17: 31944
radiation effects, 17: 31881
radiation effects on bone marrow, gamma, 17: 31931
radiation effects on mouse bone marrow, proton, 17: 31942
radioinduced chromosome aberrations in normal and tumorous, effects on viability, 17: 31897
**ANIMAL REPRODUCTION**
radiation effects in cattle, sheep, and rabbits, 17: 31816(R) (ORO-605)
radiation effects from exposure for 20 consecutive generations, in mice, 17: 31853 (LADC-5618)
radiation effects, in female dogs, 17: 31865(R) (UCD-107(p.98-111))
radiation effects on, from ingested strontium-90 in dogs, 17: 31929
**ANIMALS**
concentration of cesium-137 and calcium-45 by, 17: 31830 (TID-19127)
strontium-90 content of bones from domestic, Japan, 1957 to 1962, 17: 32300
uptake of ambient radioisotopes, survey, 17: 32276
**ANION EXCHANGE MATERIALS**
sorptive properties of Dowex-1X8 for rare earths, thorium, and uranium, 17: 32194(R) (TID-19068)
**ANIONS**
production in positive beam reactions with hydrogen, 17: 32838
**ANTARCTICA**
ages of rocks from, review of, 17: 32266
**ANTHRACENE**
luminescence, decay of slow component of, 17: 32426
**ANTIMONY**
determination of traces in selenium, activation, 17: 32020
effects of, on shielding properties of lead, 17: 33256
electron reactions with, emission spectra from, 17: 32669 (ORNL-3450)
film growth on, from reactions with cesium antimonide, 17: 32625
neutron capture cross section at 24 Mev, 17: 33005 (ORNL-TM-636)
spectra of, infrared, 17: 32739
**ANTIMONY ALLOYS**
Ga–Sb, interband Faraday rotation in, 17: 32701 (AERE-R-4341)
In–Sb, interband Faraday rotation in, 17: 32701 (AERE-R-4341)
Sb–Cr–Mn, magnetic structures in, 17: 32622
Sb–Cs, film growth on antimony from $Cs_3Sb$, 17: 32625
Sb–Cs, formation of intermetallic compound $Cs_3Sb$ in, below 130°C, 17: 32624
Sb–Cs, thermionic work functions of films of, in cesium vapor, 17: 32830
Sb–Ga, thermal conductivity, 17: 32629
Sb–Pr, vaporization of, mass spectrometric study of, 17: 32033 (CONF-20-5)
Sb–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519
**ANTIMONY ISOTOPES Sb-119**
carbon-12 reactions (carbon-12, 4n) with, half life of lanthanum-127 produced by, 17: 33023
**ANTIMONY ISOTOPES Sb-120**
carbon-12 reactions (carbon-12, 4n) with, half life of lanthanum-128 produced by, 17: 33023
**ANTIMONY ISOTOPES Sb-121**
carbon-12 reactions, (carbon-12, 4n) with, half life of lanthanum-129 produced by, 17: 33023
**ANTIMONY ISOTOPES Sb-123**
carbon-12 reactions (carbon-12, 4n) with half life of lanthanum-131 produced by, 17: 33023
**ANTINUCLEONS**
annihilation of, strange particle production cross sections in, 17: 32920
**ANTIPARTICLES**
existence of, from CP invariance and symmetry principle, 17: 32940
**ARABINOSE**
synthesis of carbon-14 labeled L-, 17: 32141
**ARGON**
analysis of plasma of, time-of-flight mass spectrometer for, 17: 33213
book: *Radiogenic Argon in Minerals and Rocks*, 17: 32278
electric conductivity measurement in seeded, 17: 33209
electric conductivity of cesium-seeded plasma of, near thermal equilibrium,

17: 33216
electric discharge in, positive column instability in, 17: 33161 (UCRL-10698)
electron avalanche growth in, visible discharge in, 17: 32786
electron beam production in plasma of, by hollow cathode discharge, 17: 32822
heat of desorption, 17: 33159(R) (ORNL-3472(p.107-18))
helium ion interactions at 0.133 to 1 Mev, free electron and ion production in, 17: 32731 (TID-19137)
ionization by protons, cross sections for, 17: 32790
performance of cesium seeded plasma of, in magnetohydrodynamic cells, 17: 32817
plasma jets of, electric current and field distribution in, 17: 33203
plasma jets of, performance of crossed-field, 17: 32835
plasma jets of, performance of Hall current, 17: 33205
plasma jets of, performance of coaxial, 17: 33207
plasma of, electric impedance of electrodes immersed in moving, 17: 33164
proton scattering by, two-electron exchange cross sections in, 17: 33077
stability of solid plutonium(IV) oxide–uranium(IV) oxide, 17: 32634

**ARGON ISOTOPES Ar-36**
energy levels of, spin assignments for, 17: 33012

**ARGON ISOTOPES Ar-38**
energy levels of, spin assignments for, 17: 33012

**ARGON ISOTOPES Ar-40**
energy levels of, spin assignments for, 17: 33012
proton scattering by, distributions from, 17: 33063

**ARGON ISOTOPES Ar-41**
range in tungsten at kev energies, 17: 32747

**ARGON SYSTEMS**
Ar–Cs, effects of magnetic field on electric conductivity of, 17: 32814

**ARMY REACTORS**
design of unmoderated gas-cooled mobile, 17: 33313 (IDO-28584(Add.1))

**ARMY REACTORS (ML-1)**
design, 17: 33361
stability analysis, 17: 33302 (AGN-TM-403)

**ARMY REACTORS (PM-1)**
core design, 17: 33361

**ARSENIC**
determination in organic compounds using oxygen flask technique, 17: 32003
determination of traces in selenium, activation, 17: 32020
effects of, on shielding properties of lead, 17: 33256

**ARSENIC ALLOYS**
As–Ga, thermal conductivity, 17: 32629
As–In, thermal conductivity, 17: 32629

**ARSENIC ISOTOPES As-74**
production by reactions on germanium isotopes, 17: 33075
use in localization of brain tumors, radiometric, 17: 31877

**ARSENIC ISOTOPES As-76**
production by reactions on germanium isotopes, 17: 33075

**ARSENIC ISOTOPES As-77**
production by reactions on germanium isotopes, 17: 33075

**ARSENIC ISOTOPES As-78**
production by reactions on germanium isotopes, 17: 33075

**ARSENIC SYSTEMS**
As–Pr, vaporization of, mass spectrometric study of, 17: 32033 (CONF-20-5)

**ARSINE**
*o*-phenylenebisdimethyl-, review on use of, 17: 32137

**ASTEROIDS**
magnetic field of Ceres, parameters for, 17: 32879

**ASTROPHYSICS**
energy equation and virial theorem for cosmic mass distributions, 17: 32853
nuclear synthesis in stars by fast-neutron capture, 17: 32869
radio emission halos of Milky Way and M31, model for, 17: 32848
radio emission sources, identification of, 17: 32847
total energy of white dwarf models, 17: 32858

**ATLANTIC OCEAN**
fallout distribution in atmosphere over, March 8 to July 2, 1961, 17: 31844
hydrographic, sediment, and faunal survey of Bogue Sound area, North Carolina, 17: 31817(R) (TID-19122)
lead content in, 17: 32274

**ATMOSPHERE**
analysis for aerosols, design chamber for, 17: 32292 (UR-629)
analysis for tritium during nuclear test moratorium, 17: 32758
cesium-137 content in, in Norway during Oct. 1957, 17: 32275
evaluation of, initial condition specification for calculating, 17: 32846
propagation of whistlers in, from nuclear explosions, 17: 32757
radioactivity content of, natural, 17: 32280
radiological monitoring in France, May 1963, 17: 32289(R) (SCPRI(RN)-1963))
solar photon reactions in, fluorescence from, 17: 32873
tritium production in, by cosmic radiation, 17: 32887

**ATOMIC ENERGY**
research programs of UKAEA, ninth annual summary, 17: 31800(R) (AP-12981)

**ATOMIC EXPLOSIONS**
detection of, microbarographic, 17: 32267
electron flux and decay of artificial radiation belt following Starfish burst, 17: 32860
fallout from, cerium-141 and -144 in, 17: 32298
mass motion in high-altitude, 17: 31803 (UCRL-7224(Rev.II))
pathological effects of, management and treatment of injuries from, 17: 32295(T) (JPRS-20511)
radio-wave spectra from, in whistler modes, 17: 32757
radioactivity from, distributions of, 17: 32276
tritium distributions from, during nuclear test moratorium, 17: 32758
use in slide-dam construction, 17: 32209 (SC-4781(RR))

**ATOMIC PHYSICS**
wave functions for atoms with Z = 1 to 10, 17: 32796

**ATOMIC STRUCTURE**
wave functions for atoms with Z = 1 to 10, 17: 32796

**ATOMS**
charged particle stopping power of complex, formula for, 17: 33223(T) (UCRL-Trans-972)
electron emission widths of, theory of, 17: 32704 (BNL-6916)
energy levels of one-electron, in high-temperature plasma, 17: 33191
photon scattering by, relativistic photoelectrons from, 17: 32810
production of meson ($\mu$), in hydrogen, 17: 33003 (NEVIS-117)

**ATROPINE**
protective effects against radiation injury of gastrointestinal tract, 17: 31896

**AURORAL STORMS**
correlation with magnetic activity, 17: 32865
electric ring currents in, guiding-center approximation for, 17: 32863
magnetic pulsations at geomagnetically conjugate points, 17: 32867
patches showing strong hydrogen lines in, 17: 32861
perturbative effects on geomagnetic fields, 17: 32864

**AZO DYES**
analytical uses of Solochromate Fast Red as spectrophotometric reagent, 17: 32194(R) (TID-19068)

## B

**BACTERIA**
radioinduced destruction of desoxyribonucleic acid, in *E. freundii* reaction mechanisms, 17: 31899
radiosensitivity of Salmonella species in eggs, 17: 31889
scavenging of sorbed material from mineral particles by, tracer study, 17: 31830 (TID-19127)

**BACTERIOPHAGES**
radiosensitivity of, 5-bromouracil-substituted DNA in, 17: 31886

**BARIUM**
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)

**BARIUM BROMIDES**
$BaBr_2$–$NaNO_3$, phase studies, 17: 32112

**BARIUM CHLORIDES**
$BaCl_2$–LiCl–NaCl, phase studies, 17: 32120

**BARIUM FLUORIDE CRYSTALS**
surface energy of {110} face of, calculation of, 17: 32749

**BARIUM ISOTOPES Ba-130**
proton reactions (p,n), half life of lanthanum-130 produced by, 17: 33023
proton reactions (p,2n) with, half life of lanthanum-129 produced by, 17: 33023
spectra of, resonance line shift relative to barium-138, 17: 33062
**BARIUM ISOTOPES Ba-132**
spectra of, resonance line shift relative to barium-138, 17: 33062
**BARIUM ISOTOPES Ba-134**
spectra of, resonance line shift relative to barium-138, 17: 33062
**BARIUM ISOTOPES Ba-135**
spectra of, resonance line shift relative to barium-138, 17: 33062
**BARIUM ISOTOPES Ba-136**
carbon-12 reactions ($C^{12}$,6n) at 120.7 Mev, samarium-142 recoil range in, 17: 33094
spectra of, resonance line shift relative to barium-138, 17: 33062
**BARIUM ISOTOPES Ba-137**
neutron inelastic scattering on, optical model for cross sections of, 17: 33048
spectra of, resonance line shift relative to barium-138, 17: 33062
**BARIUM ISOTOPES Ba-138**
carbon-12 reactions ($C^{12}$,8n) at 109.8 and 120.7 Mev, samarium-142 recoil range in, 17: 33094
spectra of, resonance line in, 17: 33062
**BARIUM ISOTOPES Ba-139**
yields from spontaneous fission of uranium-238, 17: 33109
**BARIUM ISOTOPES Ba-140**
determination in environmental samples, radiochemical, 17: 32282 (AECL-1745)
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
**BARIUM NITRATES**
$Ba(NO_3)_2$–NaBr, phase studies, 17: 32112
**BARIUM OXIDES**
BaO–$Cs_2O$–$La_2O_3$–$Li_2O$–$SiO_2$, electrochemical properties of, effects of added oxides on, 17: 32098
BaO–$La_2O_3$–$Li_2O$–$SiO_2$, electrochemical properties of glass, 17: 32097
**BARIUM STANNATES**
tin-119 Mössbauer spectra in, 17: 32107
**BARIUM TITANATE CRYSTALS**
point defect sites in, internal friction peak from symmetry splitting of equivalent, 17: 32607
**BARLEY**
radioinduced chromosome aberrations in seeds of, intensity effects on frequency of, 17: 31902
**BAROMETERS**
design of micro-, 17: 32267
**BARYONS**
properties of, survey of, 17: 32918 (UCRL-10897)
**BAUXITE**
analysis for alkaline earth oxides and metals by direct-electrolysis and precipitation, 17: 32065
**BEARING MATERIALS**
wear properties at 70 to 1900°F, survey of, 17: 32208(R) (GDC-63-140)
**BEARINGS**
performance of gas-lubricated, 17: 33149(R) (NBS-7919)
**BEHAVIOR**
radiation and age effects on dominance-submission patterns, in dogs, 17: 31864(R) (UCD-107(p.86-97))
radiation and age effects on, in dogs, 17: 31863(R) (UCD-107(p.74-85))
**BELGIAN REACTOR-3**
operation and performance, 17: 33341
**BENZENE**
effects of tritiated water on, in presence of ammonium chloride, 17: 32142
**BENZENE, CHLORO-**
effects of tritiated water on, in presence of ammonium chloride, 17: 32142
**BENZENE, FLUORO-**
effects of tritiated water on, in presence of ammonium chloride, 17: 32142
**BENZENE, NITRO-**
effects of tritiated water on, in presence of ammonium chloride, 17: 32142
iodide ion formation from iodine in, constants for, 17: 31796(R) (BNL-782(p.44-50))
**BENZENEARSONIC ACID, o-(2-HYDROXY-3,6-DISULFONAPHTHYLAZO)-, SODIUM SALTS**
reactions with lanthanum, 17: 31983
**BENZENES**
divinyl-, radioinduced film formation from, on glass and quartz, 17: 32695
**BENZILIC ACID**
benzilic acid–uranyl acetate–water, coordination compounds in, 17: 32085
**BERYLLIUM**
abundance in 3 Centauri A, 17: 32851
alloying effects on creep, hardening, and strength of uranium alloys, 17: 32657
alpha reactions (α,n) with, neutron yields from, 17: 33017
alpha reactions (α,n) with, neutron yields from, 17: 33018
atomic wave functions for, with five parameters, 17: 32786
coating of, diffusion-barrier, 17: 32574 (PWA-2184)
determination by alpha activation, 17: 32015
electronic structure, 17: 32659
electrorefining of commercial, by chloride and fluoride salt baths, 17: 32499
extrusion of, production mechanism for, 17: 32546
nuclear shapes and sizes in, 17: 33073
properties of new high-strength, 17: 32494
recrystallization effects on high-purity aluminum, 17: 32611
separation from titanium by cation exchange chromatography, 17: 32054
separation of, from bauxite by direct electrolysis and precipitation, economics of, 17: 32065
tensile properties of, at room temperature to 1600°F, 17: 32645
use in aerospace structures, 17: 32485 (MAB-193-M)
wetting by liquid metals, 17: 33323(R) (ORNL-3445(p.199-217))
x-ray yields from electron bombardment of, K, 17: 32789
**BERYLLIUM ALLOYS**
Be–Mg, fabrication of super heat-resistant, 17: 32553
Be–Pd, wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445(p.199-217))
Be–Ti, wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445(p.199-217))
Be–Ti–Zr, brazing of graphite to, 17: 32547
Be–Zr, wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445(p.199-217))
**BERYLLIUM COMPACTS**
density and electric conductivity of annealed, rolled, and sintered, 17: 32588
**BERYLLIUM COMPLEXES**
with acetylacetone, gas chromatography of fluorinated and normal, 17: 32068
**BERYLLIUM ISOTOPES Be-6**
energy levels of, properties of ground-state, 17: 33078
**BERYLLIUM ISOTOPES Be-7**
content in atmosphere over Atlantic Ocean, March 8 to July 2, 1961, 17: 31844
determination of bomb-produced, in lower stratosphere, 17: 32759
**BERYLLIUM ISOTOPES Be-8**
branching period of, calculation of, 17: 33065
detection in the ground state as a reaction product in the presence of competing reaction products, feasibility of, 17: 33054
**BERYLLIUM ISOTOPES Be-9**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
helium-3 reactions ($He^3$,α) and ($He^3$,p) at 2.0 Mev, angular distributions in, 17: 33054
lithium-6 nucleus reactions, alpha-gamma coincidence spectra, 17: 32423
oxygen-16 reactions ($O^{16}$,αγ) at 24 Mev, neon-21 energy level lifetimes from, 17: 33098
proton reactions (p,n) at 3.7 to 8.5 Mev, polarization of neutrons from, 17: 33053

**BERYLLIUM OXIDE COATINGS**
deposition and stability of, on beryllium, 17: 32574 (PWA-2184)
**BERYLLIUM OXIDE COMPACTS**
radiation effects on mechanical and physical properties of, for use as reactor moderator, 17: 33275
**BERYLLIUM OXIDE CRYSTALS**
point defect sites in, internal friction peak from symmetry splitting of equivalent, 17: 32607
**BERYLLIUM OXIDE REACTOR EXPERIMENT**
materials development for, 17: 33366 (GA-4333)
**BERYLLIUM OXIDES**
bibliography on binary and ternary systems of, 17: 32560 (AAEC/TM-199)
ceramic properties of hot-pressed and slip-cast, review on, 17: 32491
coating of, by plasma-arc spraying, 17: 32545
development and properties as reactor moderator material, 17: 33324(R) (ORNL-3445(p.218-50))
electric conductivity of, for use as insulation in thermocouples, 17: 32644
fabrication and testing, 17: 33366 (GA-4333)
mechanical flow properties at high temperatures, 17: 32614
preparation of pure sinterable, process for, 17: 32515(P)
properties of, for use in nuclear reactors, 17: 33263
radiation effects on, 17: 33366 (GA-4333)
sintering of, non-uniform shrinkage in, 17: 32582
thermodynamic properties at 298 to 1200°K, 17: 32086
BeO–$ThO_2$–$UO_2$, non-uniform shrinkage in sintering of, 17: 32582
BeO–$UO_2$, fabrication, properties, and radiation stability of, 17: 33262
BeO–$UO_2$, thermal conductivity and expansion of sintered, 17: 32585
**BETA DECAY**
nucleon-induced effects in, 17: 33095
**BETA PARTICLES**
biological effects on blood-forming elements, chronic, 17: 31930
detection and measurement of, development of ionization chamber for, 17: 32398 (CEA-2215)
detection and measurement of low-level, scintillation counter for, 17: 32410
detection and measurements, techniques for, 17: 32456
detection and measurement of, engineering drawings of counter for, 17: 32374
dosimetry using film badge, 17: 32414
effects from injected phosphorus-32 on mineral and protein metabolism, 17: 31925
**BETA SOURCES**
standardization of pure, use of complex ions in efficiency training method for, 17: 32413
**BETA SPECTRA**
analysis of, computer uses for, 17: 32481
**BETA SPECTROMETERS**
design for positron detection, 17: 32424
spherical aberration reduction in, 17: 32430
**BETA SPECTROSCOPY**
coincidence measurements using solid-state detectors, 17: 32421
computer uses in, 17: 32481
use in metal oxidation studies, 17: 32532
**BETATRONS**
design and characteristics of 18-Mev, for nondestructive testing, 17: 32610
design and operation of 31-Mev, for nondestructive testing, 17: 32609
oscillations in strong-focusing, calculation of damping constants of horizontal, 17: 33117 (LNF-63/18)
**BEVATRON**
beam extraction system for, 17: 33122 (UCRL-10868)
improvements to, 17: 33120 (UCRL-10866)
performance of, high-intensity, 17: 33121 (UCRL-10867)
**BIBLIOGRAPHIES**
on ages of Antarctic rocks, 17: 32266
on ambient radioactivity, 17: 32276
on binary and ternary systems involving beryllium oxide, 17: 32560 (AAEC/TM-199)
on composite materials, Sept. 1962 to June 1963, 17: 32482 (AD-408618)
on control systems and instrumentation of nuclear rockets, 17: 33389
on effects of weld-pool agitation on weld properties and characteristics, 17: 32533 (AD-409795)
on Faraday effect in semiconductors, 17: 32701 (AERE-R-4341)
on fluid flow and heat transfer, 17: 32257
on gamma energies from radioisotopes, 17: 32709 (IFA/SN/17)
on genetic damage in seeds from chemical mutagens and radiation, 17: 31869
on gold-198 in medicine, 17: 31814 (KFK-143)
on localized magnetic states and superconductivity in titanium-iron group alloys, 17: 32706 (CONF-23-19)
on microminiaturization in electronics, 17: 32338 (NP-12989)
on neutron-absorbing materials for reactor control, 17: 32493
on neutron physics at intermediate energies, 17: 32990
on nuclear superheat-reheat programs and concepts, 17: 33353
on publications of Inst. of Nuclear Research of Hungarian Academy of Sciences, 17: 31810
on radiation chemistry of hydrocarbons, 17: 32170
on radiation chemistry of polymers, 17: 32176
on solvent extraction of plutonium, 17: 32190 (DP-700)
on structure and composition of uranates and related uranium compounds, 17: 32049 (VDIT-77)
on uranium compounds as possible nuclear fuels, 17: 33249
on vibrational spectra of molten salts, 17: 32041 (ORNL-3413)
**BIPHENYL**
pyrolysis and radiolysis of, review on, 17: 32165
**BISMUTH**
diffusion and electric mobility of silver in, 17: 31798(R) (BNL-782 (p.60-91))
effects of, on shielding properties of lead, 17: 33256
gamma reactions on, distributions of neutrons from, 17: 33074
separation from other metals by ion exchange, 17: 32195(T) (KFK-tr-13)
**BISMUTH ALLOYS**
Bi–Pr, vaporization of, mass spectrometric study of, 17: 32033 (CONF-20-5)
**BISMUTH FILMS**
deposition of, vacuum, 17: 33158(R) (ORNL-3472(p.84-106))
magnetoresistivity, 17: 33158(R) (ORNL-3472(p.84-106))
**BISMUTH ISOTOPES Bi-207**
beta spectra measurements by solid-state detectors, 17: 32421
conversion electron-gamma coincidence spectra, 17: 32421
**BISMUTH ISOTOPES Bi-214**
content in atmosphere, 17: 32280
**BLAST EFFECTS**
from underground thermonuclear explosion, long-range, 17: 31801 (PNE-202F)
**BLOOD**
ammonia and nitrogen content during radiation sickness in rabbit, effects of glycocoll and peptone on, 17: 31975
radiation effects of phosphorus-32 applicators on peripheral, 17: 31905
radiation effects on agglutination and coagulation of, in dogs, 17: 31953
radiation effects on DNA, nucleoproteins, and RNA content in chicks, 17: 31955
radiation effects on content of natural and injected gamma globulin in, 17: 31972
**BLOOD CELLS**
radiation effects on chick, effects of folic acid, tetracycline, and vitamin $B_{12}$ on, 17: 31954
**BLOOD CIRCULATION**
development of equipment and techniques for radiocardiography studies, 17: 31818 (TID-19168)
development of equipment and techniques for radiocardiography studies, 17: 31819(R) (TID-19173)
**BLOOD COAGULATION**
radiation effects on agglutination and, in dogs, 17: 31953
**BLOOD FORMATION**
radiation effects in dogs, 17: 31930
radiation effects on, 17: 31941
**BLOOD PLASMA**
radiation effects on chemical constituents, 17: 31875
**BLOOD PLATELETS**
life span and excretion, tracer studies, 17: 31903
preparation of sulfur-35-labeled, 17: 31903

**BLOOD SERUM**
radiation effects on proteins content of, therapeutic, 17: 31907
**BLOOD VESSELS**
compression device for examiner protection during radiology of, 17: 32306
radiation effects on physiology, 17: 31874
radioinduced lesions, in hypercholesterolaemic rabbits, 17: 31900
therapy of hemangioma using phosphorus-32 applicators, effects on peripheral blood, 17: 31905
**BOILERS**
design for testing void fraction, 17: 32241(R) (ACNP-63020)
**BOILING**
acoustic noise production in nucleate, 17: 32251 (TRG-Report-549)
heat transfer in transition, development of equipment for studying, 17: 32247(R) (GEAP-4307)
thermal flux in nucleate, critical, 17: 32259
void fraction measurements in, by gamma attenuation techniques, 17: 32241(R) (ACNP-63020)
**BOILING REACTORS**
criticality studies of, poison demand curves for, 17: 33236(R) (ACNP-63022)
development of SENN, for increased power output, quarterly summary No. 3, 17: 33311(R) (GEAP-4306)
fuel cladding bursting in loss-of-coolant accident, 17: 32620
fuel element design to flatten flux distribution, 17: 33283(P)
kinetics of vapor content change in active zone in surge in reactivity in, 17: 33246
operation at vapor pressure of core solution, 17: 33297(P)
**BOLTS AND NUTS**
performance of spherical nut-clamp seat geometries for connector couplings, 17: 33362 (HW-71229)
**BONE MARROW**
effectiveness of cold-preserved, in treatment of radiation sickness, 17: 31963(T) (JPRS-20282(p.17-26))
protective effects against radiation sickness, nature of, 17: 31970
protective effects against radiation sickness in rats, 17: 31971
radiation effects on cells of, gamma, 17: 31931
radiation effects on cells of, proton, 17: 31942
transplantation effects of allogenous, on radiation damage to dogs, 17: 31969
**BONES**
radiation dosage measurements in, 17: 32305
radiation effects on, from injected plutonium-239, 17: 31926
strontium and calcium deposition in, effects of fluoride content, 17: 31841
strontium-90 content of, from domestic animals, Japan, 1957 to 1962, 17: 32300
**BORIDES**
coating with thorium dioxide by pyrohydrolysis of thorium chloride, 17: 32564 (ASD-TDR-63-635)
**BORON**
additive effects on properties of chromium–nickel steel for use as reactor heat shields, 17: 33261
alpha reactions ($\alpha$,n) with, neutron yields from, 17: 33017
alpha reactions ($\alpha$,n) with, neutron yields from, 17: 33018
atomic wave functions for, with five parameters, 17: 32796
determination by alpha activation, 17: 32015
radiation effects on stability of, effects of crystal structure on, 17: 32157
x-ray yields from electron bombardment of, K, 17: 32789
**BORON CARBIDES**
oxidation by air and water vapor at 200 to 700°C, 17: 32523
**BORON COMPOUNDS**
radiation effects on stability of, effects of crystal structure on, 17: 32157
**BORON HYDRIDES**
spectra of boron-11-labeled, infrared, 17: 32079
**BORON ISOTOPES**
separation by distillation, mass transfer in, 17: 32470
**BORON ISOTOPES B-10**
alpha reactions ($\alpha$,d), ($\alpha$,n), and ($\alpha$,p) at 4 to 11 Mev, 17: 33105
effects on corrosion of stainless steel by hydrofluoric-nitric acid, 17: 32517 (RFP-307)
neutron reactions (n,$\alpha$) with, branching ratio of, 17: 32447
reactions ($B^{10}$,7n) with lanthanum-139 at 84.4–103.7 Mev, samarium-142 recoil range from, 17: 33094
triton reactions with, cross sections for, 17: 32997 (CONF-46-79)
**BORON ISOTOPES B-11**
alpha reactions at 6.5–10 Mev, energy spectra of charged particles from, 17: 33107
nuclear magnetic resonance in metal hexaborides, Knight shifts in, 17: 32083
**BORON SYSTEMS**
B–Cr, production of, by sintering at 470 to 1150°C, 17: 32497
B–Ti, production of, by sintering at 470 to 1150°C, 17: 32497
B–Zr, production of, by sintering at 470 to 1150°C, 17: 32497
**BOSONS**
photoproduction of, pairs of, 17: 32913 (TID-7668(Sect.V))
**BRAIN**
radiation effects on electric activity in, in rabbits, 17: 31933
radiosensitivity of, effects of protective membrane on, 17: 31934
**BRAIN TUMORS**
localization, after administration of positron-emitting arsenic-74, radiometric, 17: 31877
**BRASS**
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
**BREMSSTRAHLUNG**
emission from dense plasma, photon reaction effects on rate of, 17: 33177
measurement of maximum energy of, design of circuit for, 17: 32401 (LNF-63/17)
production of, apparatus and procedures for, 17: 32914 (TID-7668(Sect. VI))
**BROMINE**
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
determination of traces in selenium, activation, 17: 32020
exchange in carbon bromides, 17: 31798(R) (BNL-782(p.60-91))
neutron radiative capture in, optical model for cross sections of, 17: 33048
proton fission at 19 Bev, lithium-8 from, 17: 33081
**BRONZE**
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
**BROOKHAVEN BEAM RESEARCH REACTOR**
beam-tube design, 17: 33379
**BUBBLE CHAMBERS**
data from, use of flying-spot film measuring machine for analysis of, 17: 32332 (BNL-6878)
development of 500-liter liquid hydrogen, 17: 32916 (TID-7668(Sect.VIII))
illumination system for 80-inch, design of, 17: 32397 (BNL-6848)
review, 17: 32412
**BUBBLES**
motion in a turbulent liquid stream, 17: 32250 (TID-19224)
**BUILDING MATERIALS**
research program of Air Force Materials Laboratory, 17: 32513
**BURNS**
induction by nuclear explosions, management and treatment of, 17: 32295(T) (JPRS-20511)
**BURROS**
radiation effects, whole-body nuclear exposure, 17: 31816(R) (ORO-605)
**BUTADIENE, CHLORO- POLYMERS**
radioinduced vulcanization of, effects of *m*-phenyldi- and *N*-phenyl maleimides on, 17: 32167
**1,3-BUTADIENE, 2-METHYL-**
radiation effects on, cosmic, 17: 32693
**BUTADIENE POLYMERS**
radioinduced vulcanization of, effects of *m*-phenyldi- and *N*-phenyl maleimides on, 17: 32167
**1-BUTANOL**
solvent properties for elements, 17: 32194(R) (TID-19068)
**2-BUTANONE**
solvent properties for thorium and uranium, 17: 32194(R) (TID-19068)

**BUTYL PHOSPHATES**
solvent properties for neodymium and ytterbium phosphates, 17: 32148
solvent properties for neodymium butyl phosphate, 17: 32149
kerosene–tributylphosphate, analysis for uranium, 17: 32000

# C

**CADMIUM**
nuclear shapes and sizes in, 17: 33073
separation from titanium by cation exchange chromatography, 17: 32054
superconductivity of, effects of pressures up to 27 katm on, 17: 32803
**CADMIUM IONS**
fluorescence of silver chloride crystals doped with, blue-green emission band shift in, 17: 32161
**CADMIUM ISOTOPES Cd-113**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
**CADMIUM ISOTOPES Cd-114**
neutron reactions with, determination of mass-flow function from, 17: 33027
**CADMIUM ISOTOPES Cd-115**
yields of isomeric, in proton fission of natural uranium at 8 to 60 Mev, 17: 33024
**CADMIUM SULFIDE CRYSTALS**
electron bombardment of, radiative recombination of free carriers produced by, 17: 32668 (NP-13019)
sulfur-35 exchange between hydrogen sulfide and, 17: 32138
**CALCINATION**
shielding calculations for Pot Calcination Demonstration at Hanford, 17: 33397 (ORNL-TM-595)
**CALCIUM**
alloying effects on mechanical properties of magnesium–manganese–thorium alloys, 17: 32595
deposition in bone, effects of fluoride content, tracer study, 17: 31841
determination in drill core samples of iron ores by x-ray fluorescence, 17: 32016
determination in potassium chloride, activation, 17: 31990
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
electronic structure, 17: 32659
metabolism in domestic animals, tracer study, 17: 31816(R) (ORO-605)
separation of scandium-49 from irradiated, 17: 32164
spectra in the solar atmosphere, intensity and velocity fluctuations in the K line in, 17: 32856
vapor pressure at 475 to 670°C, tracer study of, 17: 32050(T) (AEC-tr-5911)
**CALCIUM BORIDES**
nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083
**CALCIUM CARBIDES**
reactions with zirconium dioxide to produce zirconium, 17: 32059
**CALCIUM CYANAMIDES**
reactions with zirconium dioxide to produce zirconium, 17: 32059
**CALCIUM FLUORIDE CRYSTALS**
sintering of, dislocation movement in, 17: 32037 (CONF-50-14)
surface energy of {110} face of, calculation of, 17: 32749
**CALCIUM FLUORIDES**
casting and properties of slip-cast, for use in uranium smelting, 17: 32543
performance of uranium-activated, as lasers, 17: 32804
**CALCIUM ISOTOPES Ca-39**
neutron strengths in, single, 17: 33049
**CALCIUM ISOTOPES Ca-40**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
energy levels of, spin assignments for, 17: 33012
neutron strengths in, single, 17: 33049
**CALCIUM ISOTOPES Ca-41**
neutron strengths in, single, 17: 33049
**CALCIUM ISOTOPES Ca-44**
energy levels, 17: 32727(R) (PR-P-57(p.69-85))
**CALCIUM ISOTOPES Ca-45**
uptake by rat skeleton, effects of stable strontium on, 17: 31831(T) (JPRS-19626)
use as tracer in pulp and paper research, 17: 32328
**CALCIUM OXIDES**
separation of zirconium oxide from, as function of $SO_3$–$ZrO_2$ ratio, 17: 32077
CaO–MgO–$ZrO_2$, phase studies, 17: 32653
CaO–$ZrO_2$, grain growth of $Ca_{0.15}Zr_{0.85}O_{1.85}$, 17: 32135
CaO–$ZrO_2$, phase studies, 17: 32653
**CALCIUM SILICATES**
spectra of, infrared, 17: 32739
**CALCIUM STANNATES**
tin-119 Mössbauer spectra in, 17: 32107
**CALDER HALL REACTORS**
performance of plant components during operation, 17: 33339
**CALIFORNIUM ISOTOPES Cf-252**
spontaneous fission of, fragment energies in, 17: 32723(R) (PR-P-57(p.5-20))
spontaneous fission of, energies and fine structure in yield from, 17: 32995 (CONF-46-44)
**CALORIMETERS**
development of differential, for measurements of radioinduced power, 17: 32333 (CONF-39-53)
**CALORIMETRY**
use to measure absorbed x-ray dose, 17: 32305
**CANADA**
fallout monitoring in Toronto, 1961–62, 17: 32297
reactor fuel development in, 17: 33258
**CANDU REACTOR**
core component design for minimum cost, 17: 33282
economic analysis, 17: 33331
fuel element manufacture for, quality control program to reduce costs of, 17: 33358
steam-cycle design and economics, 17: 33356
**CARBON**
alpha reactions (α,n) with, neutron yields from, 17: 33017
alpha reactions (α,n) with, neutron yields from, 17: 33018
atomic wave functions for, with five parameters, 17: 32796
determination in coal by nuclear techniques, 17: 31985 (CONF-124-1)
determination of ratio to hydrogen in hydrocarbons, engineering drawings of analyzer for, 17: 32382
determination of total content of, in uranium, 17: 32027
diffusion from ferritic steel to austenitic stainless steel, 17: 33323(R) (ORNL-3445(p.199-217))
effects on mechanical properties of niobium, 17: 32612
effects on properties and reduction of niobium alloys, concentrates, and slags, 17: 32492
nuclear shapes and sizes in, 17: 33073
properties of, radiation effects on gas permeability and mechanical, 17: 33253
radiation effects on, cosmic, 17: 32693
x-ray yields from electron bombardment of, K, 17: 32789
**CARBON ARCS**
ion temperature of magnetically confined, 17: 33154(R) (ORNL-3472 (p.50-5))
**CARBON BROMIDES**
bromine exchange in, 17: 31798(R) (BNL-782(p.60-91))
**CARBON DIOXIDES**
cesium and rubidium deposition on metal and plastic from, 17: 32061
electron avalanche growth in, visible discharge in, 17: 32786
laminar free convection in, near the critical point, 17: 32258
oxidative effects on uranium monocarbide at 350 to 600°C, 17: 32127
radiolysis of, monoxide yields in, 17: 31794(R) (BNL-782(p.1-17))
reactions with punctured dummy fuel element at 450 and 550°C, oxidation rates in, 17: 32527
stability of solid plutonium(IV) oxide–uranium(IV) oxide, 17: 32634
Cs–$CO_2$, effects of magnetic field on electric conductivity of, 17: 32814
**CARBON ION BEAMS**
reactions with hydrogen, anion production in, 17: 32723(R) (PR-P-57 (p.5-20))
**CARBON IONS**
production in cation beam reactions with hydrogen, 17: 32838

**CARBON ISOTOPES C-12**
alpha inelastic scattering at 22.5 Mev, magnetic substates population from, 17: 33099
alpha reactions ($\alpha$,2$\alpha$) at 22.5 Mev, angular correlations for, 17: 33097
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
electron reactions (e,ep) with p and s shells of, cross sections from impulse approximation for, 17: 33037
formation in tissue, by proton activation, 17: 31851 (BNL-6989)
helium-3 reactions at 29 Mev, 17: 32153 (JEN-119-DF/I-36)
lithium-6 reactions ($Li^6$,$\alpha$), angular distributions from, 17: 33088
proton reactions (p,$\gamma$) at 10–48.5 Mev, excitation functions for nitrogen-13 ground and 3.5-Mev state from, 17: 33044
proton scattering at threshold to 48.5 Mev, excitation functions for 12.71 and 15.11-Mev states from, 17: 33043
reactions ($C^{13}$,6n) and ($C^{13}$,8n) with barium-136 and 138, samarium-142 recoil range from, 17: 33094

**CARBON ISOTOPES C-13**
reactions ($C^{13}$,$\gamma$) with fluorine-19, phosphorus-32 yield from, 17: 33060

**CARBON ISOTOPES C-14**
energy levels of, from boron-11 ($\alpha$,p) reactions at 6.5–10 Mev, 17: 33107
incorporation in organic compounds using a vacuum technique, 17: 32150
use as tracer in pulp and paper research, 17: 32328

**CARBON MONOXIDES**
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
heat of desorption, 17: 33159(R) (ORNL-3472(p.107-18))
helium ion interactions at 0.133 to 1 Mev, free electron and ion production in, 17: 32731 (TID-19137)
production from carbon dioxides, chemonuclear, 17: 31794(R) (BNL-782(p.1-17))

**CARBON STEEL**
coating with copper–nickel alloy on tubes of, technique for, 17: 32509
corrosion by mercury, 17: 31798(R) (BNL-782(p.60-91))
decontamination by oxalate–peroxide solutions, 17: 33318(R) (ORNL-3445(p.30-6))
physical properties of chromium-molybdenum, effects of air, helium, and sodium at 1100°F on, 17: 32571(R) (MSAR-63-105)
radiation effects on corrosion, mechanical, physical and thermal properties of, 17: 32679
radiation effects on plastic deformation of, 17: 32684

**CARBON SYSTEMS**
C–Cr–Co–Ni–Ti, production of, by sintering at 470 to 1150°C, 17: 32497
C–Cr–Ni, production of, by sintering at 470 to 1150°C, 17: 32497
C–Mo–Th, phase studies on arc-melted, pressure-sintered, and vacuum-annealed, 17: 32616
C–Mo–U, phase studies on arc-melted, pressure-sintered, and vacuum-annealed, 17: 32616
C–Ni–U, phase studies, 17: 32637
C–N–U, thermodynamics of formation of $UC_{1-x}N_x$ in, 17: 32132
C–O–U, fabrication and properties of sintered, 17: 32486(R) (NCSC-2663-13)
C–O–U, phase studies, 17: 32486(R) (NCSC-2663-13)
C–O–U, reactions with nitrogen, 17: 32486(R) (NCSC-2663-13)
C–O–U, thermodynamics of formation of $UC_{1-x}O_x$ in, 17: 32132

**CARCINOMAS**
radioinduced inhibition of glycolysis of Ehrlich ascites, labile phase of, 17: 31959
radiotherapy of uterine cervix, effects on leukocyte count of peripheral blood, 17: 31906

**CATALYSIS**
radioinduced, in presence of nonmetallic solids, 17: 32178

**CATHODE-RAY TUBES**
design for accurate digital length measurements on nuclear emulsions, 17: 32357

**CATIONS**
production in helium ion interactions with light elements, 17: 32731 (TID-19137)

**CATTLE**
radiation effects, whole-body nuclear exposure, 17: 31816(R) (ORO-605)

**CAVES**
construction at Munich, 17: 32211
window design using optical lenses, 17: 32235(P)

**CELLULOSE**
conference on, Syracuse, N. Y., Oct. 1962, 17: 31806
graft polymerization of, on acrylamide, ceric ion, preirradiation, and radiation methods for, 17: 31809
radioinduced graft polymerization of red pine sapwood, to polystyrene, 17: 31807
radioinduced graft polymerizations of, on polystyrene and rayon, effects of solvent additives and water on, 17: 31808

**CELLULOSE ACETATES**
graft polymerization of, on methyl methacrylate and styrene, ceric ion, preirradiation, and radiation methods for, 17: 31809
radiation effects on, cosmic, 17: 32693

**CEMENTS**
analysis for aluminum, spectrophotometric, 17: 32028

**CERAMIC MATERIALS**
bibliography on composites, 17: 32482 (AD-408618)
fabrication of rigid honeycomb structure of sintered material, 17: 32558(P)
properties and use of microspheres for radioisotopes fixation, 17: 32327
properties of, for use in nuclear reactors, 17: 33263

**CERIUM**
alloying effects on mechanical properties of magnesium–manganese–thorium alloys, 17: 32595
determination in heat-resistant alloys, photometric, 17: 32021
effects on solubility of hydrogen in iron, 17: 32597
effects on surface tension of Armco steels, 17: 32598
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
ion exchange with aluminum on Dowex 50W resin, rate of, 17: 32053
polarographic behavior in lithium sulfate, 17: 32099
separation from nitric acid solutions by ion exchange, 17: 32204(P)

**CERIUM ALLOYS**
Ce–Mg, hydrogen absorption, 17: 32643

**CERIUM BORIDES**
nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083

**CERIUM CHLORIDES**
reactions with sodium chlorides, 17: 31795(R) (BNL-782(p.18-43))
vapor pressure, 17: 32118

**CERIUM CHROMATES**
preparation of, attempts in, 17: 32102

**CERIUM FERROCYANIDES**
thermodynamics of, 17: 32117

**CERIUM HYDROXIDES**
thermal decomposition, 17: 32109

**CERIUM IONS**
separation of, parameters for cation-exchange, 17: 32092

**CERIUM(III) IONS**
determination, fluorometric technique for, 17: 31996

**CERIUM ISOTOPES Ce-141**
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
fallout of bomb-produced, in rain and snow, 17: 32298

**CERIUM ISOTOPES Ce-144**
content in atmosphere over Atlantic Ocean, March 8 to July 2, 1961, 17: 31844
fallout of bomb-produced, in rain and snow, 17: 32298
use in electrostatic space-propulsion systems, 17: 33390
use in nuclear electrogenerators for space, 17: 33391

**CERIUM NITRIDES**
properties of, electric and magnetic, 17: 32081

**CERIUM OXIDES**
entropy, 17: 32031 (BM-RI-6245)
reactions with melted fluorides, 17: 32111
thermal capacity at 50 to 298°K, 17: 32031 (BM-RI-6245)
$CeO_2$–$ZrO_2$, phase studies, 17: 32653

**CERIUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082

**CERIUM SULFIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**CERIUM TELLURIDES**
crystal structure, 17: 32125
**CESIUM**
deposition from carbon dioxide on plastic or metal, 17: 32061
determination by potentiometric titration using tetraphenyl borate, 17: 31998
electric conductivity of vaporous, effects of magnetic fields on, 17: 32814
electric conductivity of plasma seeded with, near thermal equilibrium, 17: 33216
electron and phonon scattering on, thermoelectricity in, 17: 32785
ionization on refractory metal surfaces, efficiency of, 17: 32825
performance of pure vapors of, in magnetohydrodynamic cells, 17: 32817
separation from Purex-type waste solutions by ion exchange, 17: 33396 (HW-SA-2920)
separation from wastes, using clinoptilolite, 17: 31796(R) (BNL-782 (p.44-50))
sorption by aluminum oxides and silicates, 17: 32045(R) (TID-19184)
sorption by ferric oxide and limonite, tracer studies of, 17: 32044(R) (TID-19183)
sorption by ferric silicate, 17: 32046(R) (TID-19185)
**CESIUM ALLOYS**
Cs–K, thermolelectricity from electron and phonon scattering on, 17: 32785
Cs–Rb, thermoelectricity from electron and phonon scattering on, 17: 32785
Sb–Cs, film growth on antimony from $Cs_3Sb$, 17: 32625
Sb–Cs, formation of intermetallic compound $Cs_3Sb$ in, below 130°C, 17: 32624
Sb–Cs, thermionic work functions of films of, in cesium vapor, 17: 32830
**CESIUM BROMIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
scintillation in, decay and particle-discrimination properties of, 17: 32444
**CESIUM BROMIDES**
optical properties of colloidal absorption band in, 17: 32043 (TID-19124)
**CESIUM CHLORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**CESIUM FILMS**
migration, sorption, and voltage breakdown properties of, on refractory electrodes, 17: 32827
**CESIUM FLUORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**CESIUM IODIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**CESIUM IONS**
production for propulsion systems, performance of surface-contact, 17: 32222
production on refractory metal surfaces, efficiency of, 17: 32825
**CESIUM ISOTOPES**
migration and sorption in soil, 17: 33409
**CESIUM ISOTOPES Cs-132**
production of, research on, 17: 31797(R) (BNL-782(p.51-9))
**CESIUM ISOTOPES Cs-133**
neutron radiative capture in, optical model for cross sections of, 17: 33048
nitrogen-14 reactions ($N^{14}$,5n) at 79.8 and 105.4 Mev, samarium-142 recoil range in, 17: 33094
**CESIUM ISOTOPES Cs-134**
removal from beef, 17: 31816(R) (ORO-605)
**CESIUM ISOTOPES Cs-137**
adsorption from waste solutions, ion exchange, 17: 33408
beta spectra measurements by solid-state detectors, 17: 32421
content in air, human body, and milk in Toronto, 1961–62, 17: 32297
content is atmosphere in Norway during Oct. 1957, 17: 32275
conversion electron-gamma coincidence spectra, 17: 32421
decay rate in gamma sources, tracer studies of absolute, 17: 32319 (AE-112)
determination in environmental samples, radiochemical, 17: 32282 (AECL-1745)
distributions in oceans, vertical, 17: 32273
half life of, measurement of, 17: 32719(R) (NP-12996(p.38-42))
precipitation, from highly radioactive waste solutions, 17: 33401
retention, effects of dietary potassium and sodium, 17: 31836
separation from high-level wastes, 17: 33395 (HW-SA-2786)
**CESIUM ISOTOPES Cs-138**
yields from spontaneous fission of uranium-238, 17: 33109
**CESIUM OXIDES**
$BaO–Cs_2O–La_2O_3–Li_2O–SiO_2$, electrochemical properties of, effects of added oxides on, 17: 32098
$Cs_2O–La_2O_3–Li_2O–SiO_2$, electrode properties of glass, 17: 32096
**CESIUM PLUTONIUM CHLORIDES**
preparation and properties of $Cs_2PuCl_6$ as standard for plutonium, 17: 31991
**CESIUM SILICIDES**
thermionic work functions of films of, in cesium vapor, 17: 32830
**CESIUM SYSTEMS**
Ar–Cs, effects of magnetic field on electric conductivity of, 17: 32814
$Cs–CO_2$, effects of magnetic field on electric conductivity of, 17: 32814
Cs–He, effects of magnetic fields on electric conductivity of, 17: 32814
**CESIUM TELLURIDES**
thermionic work functions of films of, in cesium vapor, 17: 32830
**CHARGED PARTICLE BEAMS**
equations for space-stationary, 17: 33137
focussing of, by axially symmetric magnetic field, 17: 32727(R) (PR-r'-57(p.69-85))
**CHARGED PARTICLES**
detection and measurement in magnetic analyzers, detector for, 17: 32428
diffusion across magnetic fields in oscillating plasma, 17: 33190
flux invariants in motion equation, 17: 32794
model for elementary, with nonzero angular momentum, 17: 32961
motion in dipole magnetic field, 17: 32878
motion in isochronous cyclotrons, betatron oscillation effects on revolution frequency of, 17: 33136
motion in magnetic mirror systems, equations for, 17: 33165
motion of, in central zone of cyclotron, 17: 33123
movement stability of, in variable magnetic field, 17: 32793
scattering by matter, energy-loss effects on multiple, 17: 32931
stopping of, by complex atoms, 17: 33223(T) (UCRL-Trans-972)
tracks in emulsion, ionization-momentum relations for, 17: 32453
**CHEMICAL ENGINEERING**
process simulation in, uses of digital computers in, 17: 32474 (IS-698)
**CHEMICAL PROPHYLAXIS**
of radiation injuries in organisms, 17: 31956
**CHEMICAL RADIATION DETECTORS**
sensitivity increase for ferric sulfate, 17: 32460
**CHEMISTRY**
developments in high-temperature, 17: 31981 (UCRL-10882)
research programs of UKAEA, ninth annual summary, 17: 31800(R) (NP-12981)
research progress at Brookhaven, 17: 31795(R) (BNL-782(p.18-43))
**CHERENKOV DETECTORS**
electronic circuitry for, design of, 17: 32438
**CHICKENS**
radiation effects on blood cells in, effects of folic acid, tetracycline, and vitamin $B_{12}$ on, 17: 31954
radiation effects on DNA, nucleoproteins, and RNA content in organs and tissues in, 17: 31955
treatment of leukemia in, using phosphorus-32, 17: 31825
**CHIMERAS**
radiation mouse, lysozyme activity in kidneys, 17: 31919
**CHLORINE**
alpha reactions ($\alpha$,n) with, neutron yields from, 17: 33017
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
use in carbonate leach process for uranium ores, 17: 32188(P)
**CHLORINE IONS**
fluorescence of silver chloride crystals doped with, blue-green emission

band shift in, 17: 32161
source for, 17: 33156(R) (ORNL-3472(p.70-4))
**CHLORINE ISOTOPES Cl-35**
energy levels, 17: 33059
**CHLOROFORM**
radiolysis of, kinetics of gamma, 17: 32155 (TID-19203)
**CHLOROPHYLLINS**
sodium, protective effects of, against radiation sickness in rabbits, 17: 31976
**CHOLESTEROL**
effects of, on radioinduced lesions of blood vessels, 17: 31900
**CHROMATOGRAPHY**
design of noncontaminating system for gas liquid, 17: 32140
equipment for, engineering drawings of gas chromatograph with ionization chamber, 17: 32381
gas, calibration of apparatus for, 17: 32384
**CHROMIUM**
abundance in 3 Centauri A, 17: 32851
alloying effects on corrosion and mechanical properties of zirconium, 17: 32484(R) (GEAP-4284)
determination of $10^{-8}$ samples of, activation method for, 17: 32026
solubility in mercury, 17: 31798(R) (BNL-782(p.60-91))
**CHROMIUM ALLOYS**
Al–Cr–Zr, oxidation and mechanical properties, 17: 32621
Cr–Cu–Fe–Ni, radiation effects on magnetic properties of, 17: 32692
Cr–Mo–Zr, oxidation and mechanical properties, 17: 32621
Cr–Nb, creep and tensile properties, 17: 32568 (CONF-53-5)
Cr–Ni, creep-rupture properties at 1300 to 1740°F, 17: 33312(R) (GEMP-215)
Cr–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
Cr–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519
Sb–Cr–Mn, magnetic structures in, 17: 32622
**CHROMIUM CARBIDES**
structural analysis of, using thermal neutrons, 17: 32057
**CHROMIUM COATINGS**
deposition and stability of, on beryllium, 17: 32574 (PWA-2184)
**CHROMIUM COMPLEXES**
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068
**CHROMIUM ISOTOPES Cr-50**
deuteron elastic scattering by, cross sections for, 17: 33071
**CHROMIUM ISOTOPES Cr-51**
decay of, branching ratio for, 17: 32724(R) (PR-P-57(p.21-36))
energy levels of, spins and transition correlations of, 17: 32725(R) (PR-P-57(p.37-43))
energy levels of, spin of, 17: 33090
**CHROMIUM ISOTOPES Cr-52**
deuteron elastic scattering by, cross sections for, 17: 33071
energy levels, 17: 32727(R) (PR-P-57(p.69-85))
**CHROMIUM ISOTOPES Cr-53**
deuteron elastic scattering by, cross sections for, 17: 33071
energy levels of, spins and transition correlations of, 17: 32725(R) (PR-P-57(p.37-43))
energy levels of, spin of, 17: 33090
**CHROMIUM ISOTOPES Cr-54**
deuteron elastic scattering by, cross sections for, 17: 33071
energy levels, transition correlation coefficients for, 17: 32725(R) (PR-P-57(p.37-43))
**CHROMIUM OXIDES**
additive effects on hardness of zirconia at room temperature, 17: 32484(R) (GEAP-4284)
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
**CHROMIUM PHOSPHATES**
preparation of colloidal phosphorus-32-labeled, for medical use, 17: 32075
**CHROMIUM STEEL**
C–Ni, radiation effects on plastic deformation of, 17: 32684
Cr–Mo, physical properties of carbonized, effects of air, helium, and sodium at 1100°F on, 17: 32571(R) (MSAR-63-105)
Cr–Ni, additive effects of boron on properties of, for use as reactor heat shields, 17: 33261
Cr–Ni, radiation effects on stress-rupture properties of tubular, 17: 33323(R) (ORNL-3445(p.199-217))
**CHROMIUM SYSTEMS**
B–Cr, production of, by sintering at 470 to 1150°C, 17: 32497
C–Cr–Co–Ni–Ti, production of, by sintering at 470 to 1150°C, 17: 32497
C–Cr–Ni, production of, by sintering at 470 to 1150°C, 17: 32497
Cr–UC, phase studies, 17: 32637
Cr–$UC_2$, phase studies, 17: 32637
**CHROMOSOMES**
fragmentation of, effects of colchicine on, 17: 31935
number of, in plants, relation to radiosensitivity of, 17: 31949
radiation and chemical effects on aberrations in potato seeds, 17: 31938
radiation effects on frequency of lethal mutations, 17: 31895
radiation effects on, genetic, 17: 31935
radiation effects on rearrangement of, in spermatogenesis in monkeys, 17: 31950
radioinduced aberrations, 17: 31897
radioinduced aberrations in, in barley seeds, intensity effects on frequency of, 17: 31902
radioinduced aberrations in mice, proton, 17: 31942
radioinduced aberrations in mouse liver cells, comparison of gamma and neutron, 17: 31958
radioinduced rearrangements during mitosis in Tradescantia, 17: 31937
**CIRCUITS**
bibliography, 17: 32338 (NP-12989)
design for electronic integrating, 17: 32395(P)
design fo: measuring maximum energy of bremsstrahlung spectrum, 17: 32-01 (LNF-63/17)
diagrams of, 17: 32336 (ISS-63/25)
**CIVIL ENGINEERING**
slide-dem construction employing nuclear explosions, 17: 32209 (SC-4781(RR))
**CIVILIAN DEFENSE**
economics and evaluation of nuclear power plants in, 17: 33361
fallout protection afforded by structures, 17: 31804 (WT-1462)
training course for personnel, 17: 31855(R) (TID-19126)
**CLOUD CHAMBERS**
design of diffusion, for fast neutron polarization measurements, 17: 32422
operation of, under normal pressure, 17: 32450
**CLOUDS**
growth in, analysis by deuterium determination in raindrops, 17: 32272
**COAL**
analysis of, survey of efficiency of nuclear techniques in, 17: 31985 (CONF-124-1)
mining and processing of, use of radioisotopes in, 17: 32320 (CONF-124-2)
**COAL DEPOSITS**
genesis of uranium-bearing, 17: 32277
**COATINGS**
for refractory metals, protective effects of, 17: 32526
**COBALT**
content in tissues, effects on radiation pathology, 17: 31928
neutron reflection from magnetized mirrors of, polarization from, 17: 32977
neutron resonance capture integral, 17: 33025
separation from manganese, by ion-exchange, 17: 31797(R) (BNL-782 (p.51-9))
separation from titanium by cation exchange chromatography, 17: 32054
spectra of, infrared, 17: 32739
**COBALT ALLOYS**
analysis for cerium, photometric, 17: 32021
Co–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
**COBALT COMPOUNDS**
with rare earths of form $ACo_3$, magnetic properties of, 17: 32819
**COBALT FILMS**
structure and magnetic properties of electrolytically deposited, 17: 32579

**COBALT ISOTOPES**
proton reactions (p,α) at 20.5 Mev on, cross sections for, 17: 33070
**COBALT ISOTOPES Co-60**
beta spectra measurements by solid-state detectors, 17: 32421
determination in cobalt isotope-iron isotope mixture, method for, 17: 31797(R) (BNL-782(p.51-9))
half life of, measurement of, 17: 32719(R) (NP-12996(p.38-42))
use in production of new industrial products with improved properties, 17: 32329
use in teletherapy, techniques and devices for, 17: 31823
**COBALT SYSTEMS**
C–Cr–Co–Ni–Ti, production of, by sintering at 470 to 1150°C, 17: 32497
**COINCIDENCE CIRCUITS**
description of junction-photomultiplier, for alpha-gamma coincidence spectra, 17: 32423
design using G-M tubes as switching elements, 17: 32425
**COINCIDENCE COUNTERS**
design and characteristics of scintillator meson telescope for cosmic rays, 17: 32419
design of variable, for radioisotope identification, 17: 32409
**COINCIDENCE MEASUREMENTS**
directional correlation measurements, variances in, 17: 33031
**COLCHICINE**
effects on chromosome fragmentation, 17: 31935
**COLLIDINES**
effects of tritiated water on, in presence of ammonium chloride, 17: 32142
**COLLIMATORS**
performance of reflecting multi-channel, as neutron beam filter and polarizer, 17: 32982
**COMPRESSORS**
development and operation of gas-bearing and grease-lubricated, 17: 33327(R) (ORNL-3445(p.329-46))
development for use in radiation-resistant pneumatic power systems for space vehicles, 17: 32208(R) (GDC-63-140)
**COMPTON EFFECT**
use for production of hard gamma beams, 17: 32960
use in nuclear resonance excitation studies, 17: 33034
**COMPUTER PROGRAMS**
DEUCO, for calculating heavy water thermodynamic properties, 17: 32038 (CVNA-129)
development of, for beta and gamma spectrum analysis, 17: 32481
extension of APT system to obtain centroids and inertias of surfaces and solids, 17: 32477 (Y-1420)
for analysis of centrifugal separators, 17: 32206(R) (ACNP-63021)
for analysis of mercury-lubricated journal bearings, 17: 32249(R) (SY-5455)
for analysis of vapor volume fractions on IBM-1620, 17: 32241(R) (ACNP-63020)
for process simulation on digital computer using analog methods, 17: 32474 (IS-698)
HACK, for correction to sensor activity for decay and burnup, 17: 33241 (HW-78131)
NDC, for burnup and reactivity calculations for rod-clustered pressure-tube lattices on IBM-704/709/7090, 17: 33238 (CVNA-146(Vols.I&II))
NUCY, for determining nuclide concentrations in reactors, revision, 17: 33244 (ORNL-TM-361(Add.))
STRZ, for calculation of steady-state temperature distribution in cylindrical body on IBM-7090, 17: 32248 (RCN-16)
UNFOLD, for analyzing linear systems by calculation of the time domain, 17: 32476 (UCRL-10927)
**COMPUTERS**
circuits for micrologic, 17: 32726(R) (PR-P-57(p.44-68))
development of equipment and techniques for radiocardiography studies, 17: 31818 (TID-19168)
development of equipment and techniques for radiocardiography studies, 17: 31819(R) (TID-19173)
model for associative memory, mathematical, 17: 32475 (SCR-641)
use in data analysis of metabolic tracer studies, 17: 31815 (LADC-5627)
use of multiparameter analyzers in nuclear physics, 17: 32348
**CONCRETES**
development and testing of high-density slag-type, 17: 33222 (ORNL-3473)
gamma-ray differential dose albedo of, calculation of, 17: 33225
gamma reflection from, factors for, 17: 33224
gamma scattering from point source in, 17: 32923
shielding properties of, 17: 33256
shielding properties of, technology of, 17: 33378
use of prestressed, in pressure vessels, 17: 33235 (AAEC/TM-198)
**CONDENSERS**
performance of air-cooled, for nuclear power plants, 17: 33303 (CEND-139)
**CONFERENCES**
Fourth Cellulose Conference, Syracuse, N. Y., Oct. 1962, 17: 31806
France-Japan Conference on Nuclear Technology, Tokyo, Nov. 12 to 14, 1962, 17: 33267
on Ionizing Radiation and the Cell, held at New York City, 1954, 17: 31881
Photon Interactions in the Bev-Energy Range, Cambridge, Mass., Jan. 1963, 17: 32908 (TID-7668)
Treatment and Storage of High-Level Radioactive Wastes, Vienna, 1962, 17: 33398
42nd Session of German Radiation Society, Hamburg, April 1961, 17: 31826
**CONGO REPUBLIC (KASAI)**
strontium–rubidium ages of minerals from rocks of Kasai basement, 17: 32269
**CONNECTORS (ELECTRIC)**
design of bayonet coupling with pivoted segment release, 17: 32240(P)
**CONSTANTS AND CONVERSION FACTORS**
for gamma exposure, flux to dose rate, 17: 31812
**CONVECTION**
analysis of unsteady heat transfer of combined free and forced, in tubes with constant axial temperature gradient at wall, 17: 32261
**CONVECTION (FORCED)**
heat transfer in, between parallel plates, 17: 32256
**CONVECTION (FREE)**
in carbon dioxide near its critical point, 17: 32258
**COPPER**
alloying effects on corrosion and mechanical properties of zirconium, 17: 32484(R) (GEAP-4284)
annealing of, electron beam for strip, 17: 32822
content in tissues, effects on radiation pathology, 17: 31928
determination in natural diamonds, activation, 17: 31995
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
determination of traces in selenium, activation, 17: 32020
deuteron-deuteron interactions on, neutron yield, 17: 32768
effects of, on shielding properties of lead, 17: 33256
electronic structure, 17: 32659
fluorescence yield of, K-shell, 17: 32724(R) (PR-P-57(p.21-36))
ion exchange with zinc on Dowex 50W resin, rate of, 17: 32053
nuclear shapes and sizes in, 17: 33073
radiation effects on plastic deformation of, 17: 32684
radiation effects on properties of, neutron, 17: 32694
reactions with fluorine at high temperatures, kinetics of, 17: 32130
separation from titanium by cation exchange chromatography, 17: 32054
wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445(p.199-217))
**COPPER ALLOYS**
Al–Cu–Mn, paramagnetism and valency in, 17: 32561 (AE-111)
Cr–Cu–Fe–Ni, radiation effects on magnetic properties of, 17: 32692
Cu–Ag, brazing of graphite to, 17: 32547
Cu–Fe, production of, by sintering at 470 to 1150°C, 17: 32497
Cu–Ge–Mn, paramagnetism and valency in, 17: 32561 (AE-111)
Cu–Mn–Zn, paramagnetism and valency in, 17: 32561 (AE-111)
Cu–Nb, preparation and properties of impregnated, 17: 32495
Cu–Ni, deposition on carbon steel tubes in feedwater heaters, 17: 32509
Cu–Ta, preparation and properties of impregnated, 17: 32495
**COPPER COMPLEXES**
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068
**COPPER FOILS**

electron reactions with, emission spectra from, 17: 32669 (ORNL-3450)
**COPPER ISOTOPES**
proton reactions (p,α) at 20.5 Mev on, cross sections, 17: 33070
**COPPER ISOTOPES Cu-63**
energy levels of, Coulomb excitation of, 17: 32723(R) (PR-P-57(p.5-20))
neutron reactions (n,α) on, neutron dosimetry by, 17: 32294(T) (CEA-tr-A-1221)
properties for neutron dosimetry, 17: 33000 (CONF-67-15)
**COPPER ISOTOPES Cu-64**
use as tracer in pulp and paper research, 17: 32328
**COPPER ISOTOPES Cu-65**
energy levels of, Coulomb excitation of, 17: 32723(R) (PR-P-57(p.5-20))
energy levels of, lifetimes of, 17: 33076
**CORTISONE**
protective effects against radiation injury of gastrointestinal tract, 17: 31896
**COSMIC ALPHA PARTICLES**
flux of primary, at 55°N, 17: 32891
**COSMIC ELECTRONS**
energy distributions in extensive air showers, 17: 32890
losses in Van Allen belts due to whistlers, 17: 32889
production by cosmic proton interactions in space, 17: 32886
properties of geomagnetically trapped, from nuclear explosions, 17: 32845 (UCRL-7309(Rev.I))
**COSMIC MESONS (μ)**
intensities in ocean depths, 17: 32718(R) (NP-12996(p.36-7))
**COSMIC NEUTRONS**
intensities in ocean depths, 17: 32718(R) (NP-12996(p.36-7))
program developments at Chalk River, 17: 32724(R) (PR-P-57(p.21-36))
**COSMIC PARTICLES**
intensity variations of heavy solar, diffusion model for, 17: 32885
interactions with geomagnetic plasma, vlf radiation from, 17: 32868
reactions of nuclear, at 5000 Bev, 17: 32893
spectra of nuclear-active, at 3260 m altitude, 17: 32892
**COSMIC PHOTONS**
energy distributions in extensive air showers, 17: 32890
**COSMIC PROTONS**
electric ring currents in geomagnetically trapped, 17: 32863
intensity variations of solar, diffusion model for, 17: 32885
interactions with interstellar protons, cosmic electrons from, 17: 32886
reactions with planetesimals, helium-3 from, 17: 32866
**COSMIC RADIATION**
detection and measurement of, design of very large boron trifluoride proportional counters for, 17: 32447
detection and measurement, 17: 32290(R) (TID-19111)
diurnal and seasonal variations, 17: 32290(R) (TID-19111)
effects on corn seeds from satellite flights, 17: 31947
effects on space vehicles, NASA laboratory for studies of, 17: 32699
interactions with Martian atmosphere, biological implications of neutron production in, 17: 32881
reactions in atmosphere, tritium production by, 17: 32887
simulation of, for space-environment studies, 17: 32884 (AEDC-TDR-63-118)
sources of r-f, identification with stellar objects, 17: 32847
**COSMIC-RAY SPECTRA**
determination at 3260 m altitude, for nuclear-active particles, 17: 32892
**COSMIC-RAY SPECTROMETERS**
description of total-absorption, 17: 32439
**COSMIC SHOWERS**
electron and photon energy distributions in extensive, 17: 32890
**COSMOLOGY**
effects of neutrino processes on late stages of stellar evolution, 17: 32850
energy equation and virial theorem for cosmic mass distributions, 17: 32853
evolution of central stars of planetary nebulae, 17: 32849
production of helium-3 by proton bombardment of planetesimals, 17: 32866
total energy of white dwarf models, 17: 32858
**COTTON**
radiation effects on grafting monomers onto, 17: 32329
**CRATERS**
nuclear, distribution of ejecta on ground surrounding, 17: 31802 (PNE-217F)
**CREEP**
equipment for measuring rate of, in fast neutron field, 17: 32697
**CRITICAL ASSEMBLIES**
hazards evaluation for Advanced Pressure Tube Reactor, 17: 33373 (NP-12998)
reactivity of, use of pulsed neutron source measurements for determining, 17: 32894 (CONF-39-47)
**CRITICALITY STUDIES**
handbook, 17: 32293 (Y-1272)
of plutonium solutions, 17: 32895 (HW-SA-2999)
**CROSS SECTIONS**
research activities at ORNL, 17: 33005 (ORNL-TM-636)
transformation of systems for, using T-matrices, calculations of elements in, 17: 32919 (WAPD-T-1579)
**CROTONALDEHYDE**
nuclear magnetic resonance spectra of trans isomer of, use of Overhauser effect in analysis of high resolution, 17: 32129
**CRYOGENICS**
developments in Sherwood Project, 17: 33149(R) (NBS-7919)
**CRYOSTATS**
detection of solidified air in, device for, 17: 32353
**CRYSTAL STRUCTURE**
distribution functions for grain orientations in metals, 17: 32631
**CRYSTALS**
gamma absorption by impurity nucleus in Bravais, no-phonon and one-phonon cross sections for, 17: 33096
lattice interactions in Ising model for ferromagnetic, long-range forces in, 17: 32764
Mössbauer line intensity from impurity source in, mass-independent derivation for, 17: 32056
nuclear Mössbauer effect in infinite, 17: 33084
radioinduced anion defects or color centers in ionic, 17: 32671 (ZFK-WF-22)
solid solutions in bcc, interstitial, 17: 32618
surface energy of the {110} face of, with fluorite structure, 17: 32749
x-ray diffraction of mosaic, secondary extinction coefficient for, 17: 32829
**CURIUM ISOTOPES**
neutron fission of, average number of fission neutrons in, 17: 33016
**CURRENT INTEGRATORS**
design, 17: 32395(P)
design of transistorized low-impedance, 17: 32356
**CYCLOHEXANE, HEXACHLORO-**
analysis for the gamma isomer, isotope dilution, 17: 32029
**CYCLONE SEPARATORS**
design and development of centrifugal downflow, for air-water and steam-water systems, 17: 32206(R) (ACNP-63021)
**CYCLOPENTADIENYL COMPOUNDS**
with zirconium, containing acyloxy groups, 17: 32144
**CYCLOTRONS**
injection of electrons into microtrons, device for, 17: 33129
ion-beam acceleration by, effects of parameters on phase and duration of, 17: 33124
ion motion in central zone of, 17: 33123
ion sources for, description of hot-cathode filamentless, 17: 33133
particle revolution frequency in isochronous, betatron oscillation effects on, 17: 33136
**CYLINDERS**
heat transfer in turbulent flows through heated annuli, 17: 32255
superconductivity of hollow, magnetic field effects on, 17: 32809
**CYSTEINE, S-(DICHLOROVINYL)-**
synthesis of tritiated, 17: 32143
**CYSTINE**
radiolysis of aqueous solutions of, effects of sodium chloride on ammonia yield in, 17: 32158
**CYTOCHROME OXIDASE**
radiation effects on activity of, in liver, nervous system, and skeleton in rabbits, 17: 31979
**CYTOLOGY**
radiation effects on cells, 17: 31881
**CYTOSINE**

*O*-methyl-, anionic effects in photolysis of, 17: 32159
photolysis of, anionic effects in, 17: 32159

# D

**DATA RECORDING SYSTEMS**
development for bubble and spark chambers, 17: 32915 (TID-7668(Sect. VII))
**DATA TABULATIONS**
activity coefficients of dilute binary liquid-metal solutions, 17: 32633
deuteron reactions (d,d) and (d,p) and proton scattering, angular distributions and polarizations for, 17: 33036
gamma energy of radioisotopes formed by thermal neutron activation of natural isotopes, 17: 32709 (IFA/SN/17)
neutron transmission coefficients, optical-model, 17: 32968(BNL-765)
**DECAY SERIES**
quantum mechanics and two-step, 17: 33069
**DECONTAMINATION**
of inorganic and organic materials, use of ultrasonics for, 17: 32304
**DENSITOMETERS**
design and performance of x-ray, for liquids, 17: 32386
development of floating radiometric, 17: 32321
**DEUTERIUM**
atom pairings in tritiated, electron paramagnetic resonance study of, 17: 32042 (TID-19123)
determination in raindrops, 17: 32272
determination of, in water by measurement of variation of vanadium electrode potential, 17: 31989
deuteron reactions (d,n) with, neutron polarization in, 17: 32996 (CONF-46-78)
electric discharge in, electrode sheath effects on, 17: 32734 (UCRL-7357)
electric discharge in, positive column instability in, 17: 33161 (UCRL-10698)
electron temperature in theta pinch in plasma of, from impurity line radiation, 17: 33214
embrittlement and permeation of SAE 4130 steel by, 17: 32521
embrittlement effects on SAE 4130 steel, effects of gas content on, 17: 32522
incorporation into methyl groups of 2,2-dimethylpropionic acid, 17: 32151
isotope effects on ionization constants of carboxylic acids, 17: 32151
properties of high-vacuum arc plasma, 17: 33154(R) (ORNL-3472(p.50-5))
separation by catalytic isotope exchange between hydrogen and water in hot-cold columns, 17: 32473(P)
**DEUTERIUM SYSTEMS**
D–Zr, phase studies, 17: 32580
**DEUTERONS**
emission in alpha reactions (α,d) with lithium-6 at 23.7 and 24.5 Mev, angular distributions for, 17: 33014
interactions with deuterons on copper, heavy ice, and titanium, neutron yields, 17: 32768
interactions with neutrons at 1.0 Mev, polarization in elastic, 17: 32935
interactions with neutrons, matrix elements of the Hamiltonian in, 17: 32937
interactions with nucleons, phase-shift ambiguities in, 17: 32946
interactions with protons, gamma distribution and yield from, 17: 33003 (NEVIS-117)
production in high-energy proton reactions with nuclear emulsion, 17: 33091
reactions (d,d) and (d,p), angular distributions and polarizations for, 17: 33036
reactions (d,n) with deuterium, neutron polarization in, 17: 32996 (CONF-46-78)
reactions (d,p) with sodium-23 at 7.8 Mev, 17: 33055
reactions (d,p) with nuclei, cross sections and energy levels from, 17: 33066
reactions (d,p) with nuclei, Coulomb interaction effects in, 17: 33067
reactions on germanium isotopes, arsenic isotopes from, 17: 33075
reactions on plutonium and uranium isotopes, fission from, 17: 33082
scattering by chromium and zinc isotopes, cross sections for, 17: 33071
scattering on aluminum-22, differential and total cross sections for splitting in, 17: 33068
scattering on nitrogen-14 at 0.7–2.1 Mev, angular distributions and cross sections for, 17: 33086
transitions in water-*d* and water-$d_2$, two-quantum, 17: 32765
**DIAMONDS**
analysis for copper, manganese, and sodium in natural, activation, 17: 31995
point defect sites in, internal friction peak from symmetry splitting of, 17: 32607
**DIFFERENTIAL EQUATIONS**
expansions for pair of singular first-order, 17: 32479
**DIFFUSION**
coefficients of gaseous, effects of mixing ratio on, 17: 32052(T) (AEC-tr-5938)
**DIODES**
performance of germanium and silicon, in logarithmic amplifiers, 17: 32349
radiation effects on gallium arsenide, degradation of luminescence following, 17: 32672
radiation effects on germanium and silicon, neutron, 17: 32680
**DIOXANE**
effects of, on solvent effects in hydrolysis of tert-butyl chloride in heavy and light water, 17: 32063
solvent properties for thorium and uranium, 17: 32194(R) (TID-19068)
**DISSOLVERS**
performance of 304L and 309SCb stainless steel electrolytic, for dissolution of clad fuel elements, 17: 32192(R) (DP-839)
**DISTILLATION**
use of vacuum, in radiochemical separations, 17: 32154 (NAS-NS-3120)
**DOGS**
age effects on physical condition, 17: 31859(R) (UCD-107(p.13-29))
care of aging, 17: 31858(R) (UCD-107(p.7-12))
heart disease incidence, effects of irradiation and age, 17: 31862(R) (UCD-107(p.50-73))
radiation and age effects on, 17: 31867(R) (UCD-107(p.129-274))
radiation and age effects on eyes, 17: 31861(R) (UCD-107(p.44-9))
radiation effects, long-term, 17: 31859(R) (UCD-107(p.13-29))
radiation effects on spermatogenesis in, 17: 31929
radiation effects on blood-forming elements in, 17: 31930
radiation effects on blood agglutination and coagulation in, 17: 31953
radiation effects on kidneys in, protective effects of unithiol against, 17: 31968
radiation effects on, effects of allogenous bone marrow transplantation on, 17: 31969
radiation effects on work capacity and longevity, 17: 31857(R) (UCD-107)
**DRESDEN POWER REACTOR**
operation experience in 1962, 17: 33352
**DROSOPHILA**
mutagenic effects of formaldehyde food and x rays in spermatogenesis of, 17: 31892
radiation effects on occurrence frequency of, mutations in, 17: 31936
radiation induced mutational response in, gamma, 17: 31894
radiation induced mutation rates in sperm of, x, 17: 31895
**DRY BOXES**
design for plutonium fabrication, 17: 32537 (HW-SA-2904)
**DUNITES**
mass spectrum of secondary ions from, 17: 32389
**DUSTS**
radioactivity of, sampling techniques for determining, 17: 32310
removal from an object or clothing, design of chamber for, 17: 32318(P)
**DYES**
radiation effects on tissue reaction to injected, in rabbits, 17: 31924
**DYSPROSIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
paramagnetic-antiferromagnetic transition of, effects of pressure on, 17: 32748
spectra of, infrared, 17: 32739
thermal capacity at 3 to 30°K, 17: 32654
**DYSPROSIUM ALLOYS**
Dy–Zr, magnetic properties of, 17: 32651
**DYSPROSIUM BORATES**

$DyBO_3$–$LaBO_3$, structural polymorphism of, 17: 32124
**DYSPROSIUM CHELATES**
luminescence decay times and spectra of, 17: 31980 (CONF-37-4)
**DYSPROSIUM CHLORIDES**
vapor pressure, 17: 32118
**DYSPROSIUM NITRIDES**
electric and optical properties, 17: 32652
properties of, electric and magnetic, 17: 32081
**DYSPROSIUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**DYSPROSIUM SULFIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**DYSPROSIUM TELLURIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082

# E

**EARTH**
core rotation in, magnetic field production by dynamo action of, 17: 32874
**ECOLOGY**
natural background radiation as related to population distribution in Switzerland, 17: 31829
of Bogue Sound area, North Carolina, 17: 31817(R) (TID-19122)
radiation effects on, of pine-oak forest, single and chronic gamma exposure, 17: 31854(R) (TID-19067)
**EGGS**
radiosensitivity of Salmonella bacteria in, 17: 31889
radiosensitivity of oocytes at different maturation stages in rats, 17: 31913
**ELASTOMERS**
physical properties of, effects of composition, environment, ionization, and radiation on, 17: 32683
radiation effects on, cosmic, 17: 32693
**ELECTRIC CURRENTS**
distributions of diamagnetic, in geomagnetic fields, 17: 32863
magnetic field distributions around cylindrical arrangements of, helically symmetric, 17: 32797
**ELECTRIC DISCHARGE**
electron beam production by hollow cathode, in plasma, 17: 32822
ion temperatures in PIG reflex, measurements of, 17: 33168
light emission from sliding spark gap in high vacuum, 17: 32710 (JUL-123-PP)
shock wave production by, in spark gaps, 17: 32801
stability of intense pulsed, electrode sheath effects on, 17: 32734 (UCRL-7357)
stability of Penning-type, in weakly ionized plasma columns, 17: 33176
stability of reflex, effects of long-wavelength instabilities on, 17: 33147 (MATT-198)
stability of the positive column in a time-dependent magnetic field, 17: 33142 (D1-82-0218)
**ELECTRIC FIELDS**
plasma oscillations in external, 17: 33172
plasma oscillations in external, quasi-linear theory of, 17: 33179
**ELECTRIC GENERATORS**
description of nuclear, for space power uses, 17: 33391
**ELECTRIC MOMENTS**
interactions with ions, angular collective variables for energy of dipole, 17: 32795
**ELECTRIC POWER**
generation by hydroelectric plants and transmission of, cost trends in, 17: 32216
**ELECTRIC PROBES**
design and performance of gridded, 17: 33152(R) (ORNL-3472(p.9-23))
plasma wave excitation by grid pair, 17: 33183
response of Langmuir, in high magnetic fields, 17: 33145 (MATT-157)
**ELECTROCHEMISTRY**
radiation, mechanism of rate change in, 17: 32171
**ELECTRODEPOSITION**
book: *Electrodeposition of Alloys. Principles and Practice.* Vol. I, 17: 32510
book: *Electrodeposition of Alloys. Principles and Practice.* Vol. II, 17: 32511
**ELECTRODES**
sheaths of, effects on high-current discharges, 17: 32734 (UCRL-7357)
**ELECTROLYTIC SEPARATION PROCESSES**
performance for reactive metals, 17: 32504
**ELECTROMAGNETIC FIELDS**
Green tensor functions for, in anistropic media, 17: 32799
interactions with point electrons, 17: 32720 (NP-13004)
isospin properties, 17: 32943
**ELECTROMAGNETIC WAVES**
interactions with solids, electric and thermal effects of, 17: 32674
propagation in compressible plasma, 17: 33141 (AD-410077)
propagation in plasma waveguide, 17: 33185
propagation through plasma slabs, in magnetic field, 17: 33218
reflection by plasma half-space, 17: 33181
whistler propagation in plasma, thermal cutoff to, 17: 33143 (D1-82-0229)
**ELECTROMAGNETISM**
theory of, Maxwell equations as operators in, 17: 32798
**ELECTRON BEAMS**
acceleration in linacs, optimization of parameters for, 17: 33135
acceleration of, effects of radiation damping on, 17: 33127
effects on hair pigmentation, 17: 31882
interactions with plasma ions, magnetic field effects on energy gain in, 17: 33194
interactions with plasma, 17: 33153(R) (ORNL-3472(p.24-49))
production by hollow cathode discharge in plasma, 17: 32822
production of polarized, techniques for, 17: 32914 (TID-7668(Sect.VI))
therapeutic use of high-energy, pencil beam scanning, 17: 31870
thermal effects on solids, calculation of surface temperature in, 17: 32821
trajectories in electron microscopes, caustic and shadow, 17: 32346
use in radiotherapy, shielding requirements for, 17: 31824
**ELECTRON MICROSCOPES**
beam trajectories in, caustic and shadow image patterns for tracing, 17: 32346
**ELECTRON PAIRS**
production at wide angles, 17: 32916 (TID-7668(Sect.VIII))
production by linearly polarized photons, cross sections for, 17: 32711 (LNF-62/113)
production in thick converters at electron energies of 30 and 200 Mev, Monte Carlo calculation, 17: 32713 (LNF-63/27)
transition to quasi-particle excitations in superconductors, 17: 32839
**ELECTRON SHOWERS**
avalanche growth in gases, visible discharges in, 17: 32786
**ELECTRON SOURCES**
description of resonant-circuit, for microtrons, 17: 33129
**ELECTRONIC EQUIPMENT**
circuit diagrams and properties of, 17: 32336 (ISS-63/25)
design for measuring average amplitude of pulse spectra, 17: 32354
design of bias unit for expanding pulse-height spectrum for kicksorter, 17: 32355
design of integrating circuit for, 17: 32395(P)
development of transistorized, for linear accelerators and Van de Graaff generators, 17: 32347
**ELECTRONICS**
bibliography on research on, at Hungarian Academy of Sciences, 17: 31810
developments at Chalk River, 17: 32726(R) (PR-P-57(p.44-68))
microminiaturization in, bibliography on, 17: 32338 (NP-12989)
**ELECTRONS**
capture by protons in hydrogen, cross sections for, 17: 33061
cyclotron resonance of, as energy source for plasma acceleration, 17: 33204
density perturbations of, in mixing of two different plasmas, 17: 33193
density profiles in ionospheric F2 layer, effects of temperature changes on, 17: 32870

electric field parameters from orbital, in rare earth crystals, 17: 32090
emission from gamma-irradiated metals, 17: 32726(R) (PR-P-57(p-44-68))
emission of, theory of reduced widths in, 17: 32704 (BNL-6916)
energy absorption by cyclotron resonance of, from microwave gyro-interactions in magneto-plasma, 17: 33215
energy distribution functions of ionospheric, 17: 32882
intensity decay rate and spatial distribution of geomagnetically trapped, from high-altitude explosions, 17: 32279
interactions of point, with radiation fields, 17: 32720 (NP-13004)
interactions with photons, relativistic photoelectrons from, 17: 32810
interactions with protons at 950 Mev, proton polarization in, 17: 32905 (LAL-1072)
interactions with protons, photon Regge trajectory in, 17: 32911 (TID-7668(Sect.III))
interactions with electrons, cross section for, 17: 32916 (TID-7668 (Sect.VIII))
interactions with positrons, meson ($\pi$) pair production in, 17: 32958
interactions with gamma radiation, use for production of hard gamma beams, 17: 32960
motion in logarithmic electrostatic potential field, characteristics of orbital, 17: 32820
production in helium ion interactions with light elements, 17: 32731 (TID-19137)
reactions (e,ep) with carbon-12 p and s shells, cross sections from impulse approximation for, 17: 33037
reactions in supernova processes, neutrino emission from, 17: 32880
reactions with hydrogen, ionization by impact, 17: 33155(R) (ORNL-3472(p.56-69))
reactions with metal foils, emission spectra from, 17: 32669 (ORNL-3450)
reactions with nuclei, cross section for meson ($\pi$) production in, 17: 32913 (TID-7668(Sect.V))
recombination with oxygen ions in presence of nitrogen atoms, rate for three-body, 17: 32816
scattering on cesium, rubidium, and their alloys, thermoelectricity in, 17: 32785
scattering on hydrogen atoms, resonance energies for, 17: 32788
slowing-down spectra of fast, in matter, 17: 32826
spin in Riemannian space, relativistic theory of, 17: 32963
spins in magnetic and radiofrequency fields, 17: 32754
temperature in plasma, calculation from power balance, 17: 33154(R) (ORNL-3472(p.50-5))
temperatures in plasma afterglow, gated microwave radiometer for, 17: 33217
temperatures in theta pinch, from impurity line radiation, 17: 33214
wave equation in general relativity, formulation of, 17: 32735(T) (UCRL-Trans-981)

**ELECTROPHORESIS**
mechanism of, in nitrilotriacetic acid, 17: 32196(T) (UCRL-Trans-973)

**ELECTROPHOTOGRAPHY**
use of xerographic process in autoradiography, 17: 32352

**ELECTROSTATIC ANALYZERS**
power supply for, design of stabilized ±20 kv, 17: 32370

**ELECTROSTATIC FIELDS**
electron orbital motion in logarithmic potential of, characteristics of, 17: 32820

**ELECTROSTATIC LENSES**
image-forming characteristics of periodic field, for ions, 17: 32369

**ELECTROSTATIC PRECIPITATORS**
efficiency for radioactive dusts, 17: 32280

**ELEMENTARY PARTICLES**
book: *The Optical Model in Nuclear and Particle Physics*, 17: 33108
classification of, $SU_3$ representations for, 17: 32896 (ANL-6729)
emission in meson ($\mu$) decay, relativistic three-body, 17: 32921
ground state properties of system of, method for calculating, 17: 33227 (NYO-10431)
interactions at high energies, models for, 17: 32952
interactions in unitary-symmetry theory, weak, 17: 33233
interactions of composite, formulation of many-body, 17: 32929
interactions of, symmetries shared by strong and weak, 17: 32936
interactions of, theory, 17: 32910 (TID-7668(Sect.II))
interactions of three-body system of, two-body methods for, 17: 32922
interactions with tetradimensional isobaric symmetry, measurement invariants for strong, 17: 32924
model for charged, with nonzero angular momentum, 17: 32961
motion in one-dimensional square-well potential, propagator for, 17: 32938
quantum field theory of, of zero rest mass, 17: 32925
scattering of, partial wave amplitude uniqueness in, 17: 32904 (EPIC-63-40)
symmetries of, axiomatic theory of, 17: 32943
theory of, parameterization of local operators in, 17: 32953
theory of, quaternion approach to, 17: 32715(R) (NP-12996(p.1-22))
theory of, quaternion approach to, 17: 32716(R) (NP-12996(p.23-8))
transition amplitudes above creation threshold of more than two, calculation of, 17: 32944
vector mesons as Regge poles in perturbation theory, 17: 32902 (EPIC-63-35)
wave functions for systems of identical, 17: 32930

**ELEMENTS**
abundance in 3 Centauri A, 17: 32851
abundance of metallic, in $\zeta$ Herculis and G dwarfs, 17: 32852
determination of light, by alpha activation, 17: 32015
synthesis by stellar neutron capture, evidence for, 17: 32883
synthesis in stars by fast-neutron capture, 17: 32869

**ELK RIVER POWER REACTOR**
control rod worth measurements and reactivity, 17: 33354
design of, technical specifications for, 17: 33315 (NP-12999)
operation of, technical qualifications of personnel for, 17: 33328 (TID-19066)

**EMISSION SPECTRA**
use for isotopic abundance measurements, 17: 32023

**ENZYMES**
activity in lungs, effects of adrenal gland irradiation and pertussis sensitization, 17: 31910
association with DNA in *E. coli* of, 17: 31832
radiation effects on tyrosine oxidase system, in rats, 17: 31884(T)
radiation effects in *E. coli*, x-, 17: 31960
radioinduced inactivation of aldolase, 17: 31961

**EPIDEMIOLOGY**
of radiation sickness effects on immunity, 17: 31977

**EQUATION OF STATE**
hyper-chain, of a hard-sphere gas, 17: 32778
use of Becker-Kistiakowsky-Wilson, in computing detonation properties of condensed explosives, 17: 32039 (LA-2900)

**EQUIPMENT AND PROCEDURES**
design for electrical measurements through vessel walls without direct connections, 17: 32230(P)

**ERBIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
electrochemical properties in phosphoric acid, 17: 32034 (CONF-2[illegible])

**ERBIUM ALLOYS**
Er–Zr, magnetic properties of, 17: 32651

**ERBIUM BORATES**
$ErBO_3$–$LaBO_3$, structural polymorphism of, 17: 32124

**ERBIUM CHLORIDES**
vapor pressure, 17: 32118

**ERBIUM NITRIDES**
electric and optical properties, 17: 32652
properties of, electric and magnetic, 17: 32081

**ERBIUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082

**ERBIUM SULFIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081

**ERBIUM TELLURIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082

**ESCHERICHIA COLI**
deoxynucleotide polymerase–DNA in, 17: 31832

radiation effects on enzymes in, x-, 17: 31960
radiosensitivity of 5-bromouracil-substituted DNA in, uv, 17: 31885
**ESTROGENS**
protective effects against radiation damage to blood formation in mice, 17: 31941
**ETHANETHIOL, 2-AMINO-**
distribution in tissues in rats, tracer study of, 17: 31943
dose reduction factor for, with mitotic index of rat bone marrow as reference system, 17: 31909
effects on chromosomic structures and properties in *Pisum sativum*, 17: 31888
effects on enzymatic activity of irradiated pepsin, 17: 31940
protective effects against radiation damage in mice, correlation of dose with, 17: 31966
protective effects against radiation effects on muscles in mice, 17: 31967
reaction of normal and malignant tissues to, 17: 31939
toxic effects in mice, modification by x irradiation, 17: 31898
**ETHANOL**
solvent additive effects on radioinduced graft polymerization of cotton cellulose and rayon on polystyrene, 17: 31808
solvent properties for elements, 17: 32194(R) (TID-19068)
**ETHYL ETHER**
solvent properties for aluminum, iron, thorium, and uranium, 17: 32194(R) (TID-19068)
**ETHYL SULFATES**
genetic effects of x rays and, on seeds, 17: 31869
**ETHYLAMINE, 2,2'-DITHIOBIS-**
effects on oxygen balance in man, 17: 31833
protective effects against radiation damage in mice, correlation of dose with, 17: 31966
**ETHYLENE**
radiation effects on, cosmic, 17: 32693
radiation polymerization of, 17: 31796(R) (BNL-782(p.44-50))
radioinduced polymerization with chlorotrifluoroethylene, 17: 32179
**ETHYLENE, CHLORO-**
radiation effects on, cosmic, 17: 32693
**ETHYLENE, CHLORO- POLYMERS**
radioinduced vulcanization of, effects of *m*-phenyldi- and *N*-phenyl maleimides on, 17: 32167
spectra of deuterated and normal, assignments for, 17: 32606
**ETHYLENE, CHLOROTRIFLUORO-**
radiation effects on, cosmic, 17: 32693
radioinduced polymerization with ethylene, 17: 32179
**ETHYLENE POLYMERS**
coating with cesium and rubidium by deposition from carbon dioxide, 17: 32061
neutron attenuation in slabs of, fast, 17: 32988
radiation effects on, cosmic, 17: 32693
radioinduced vulcanization of, effects of *m*-phenylenedi- and *N*-phenyl maleimides on, 17: 32167
shielding properties of, 17: 33256
**ETHYLENE, TETRAFLUORO-**
radiation effects on, cosmic, 17: 32693
**ETHYLENEDIAMINE COMPLEXES**
with scandium chlorides, formation mechanism, 17: 32147
**ETHYLENIMINE**
effects on viability and chromosome aberration in potato seeds, 17: 31938
**EUROPIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
**EUROPIUM BORATES**
$EuBO_3$–$LaBO_3$, structural polymorphism of, 17: 32124
**EUROPIUM BORIDES**
nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083
**EUROPIUM CHELATES**
luminescence decay times and spectra of, 17: 31980 (CONF-37-4)
**EUROPIUM CHLORIDES**
vapor pressure, 17: 32118
**EUROPIUM COMPLEXES**
with DTPA, formation and stability constants of, 17: 32110
**EUROPIUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**EUROPIUM OXIDES**
phase transformations in, 17: 32058
solubility in boiling water, 17: 32058
$Eu_2O_3$–$PuO_2$, phase studies, 17: 32572 (NP-13003)
$Eu_2O_3$–$UO_2$, phase studies, 17: 32572 (NP-13003)
**EUROPIUM SELENIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**EUROPIUM SULFIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**EXOSPHERE**
magnetopause in, nature and processes of, 17: 32876
**EXPERIMENTAL BOILING WATER REACTOR**
core performance during operation at zero power to 100 Mw, 17: 33345
**EXPERIMENTAL BREEDER REACTOR-II**
design, 17: 33361
**EXPERIMENTAL GAS COOLED REACTOR**
component and materials irradiation testing, 17: 33320(R) (ORNL-3445 (p.63-108))
component development and testing, 17: 33318(R) (ORNL-3445(p.30-6))
criticality studies and performance analyses, 17: 33317(R) (ORNL-3445 (p.3-29))
design of, review of, 17: 33305 (CONF-39-49)
development of, Oct.–Mar. 1963, 17: 33316(R) (ORNL-3445)
fuel element development, 17: 33319(R) (ORNL-3445(p.37-62))
fuel elements for, fluid flow and heat transfer in 7-rod cluster of, 17: 33326(R) (ORNL-3445(p.298-328))
materials development, 17: 33319(R) (ORNL-3445(p.37-62))
pressure vessel stress analysis of, models for, 17: 33252
**EXPLOSIONS**
pressure from atmospheric, height effect on, 17: 32728 (SC-4687(RR))
**EXPLOSIVES**
detonation properties of condensed, computation of, 17: 32039 (LA-2900)
**EXTRACTION APPARATUS**
design and development of centrifugal downflow, for air-water and steam-water systems, 17: 32206(R) (ACNP-63021)
residence times of solutions in, for zirconium separation from uranium, 17: 32191 (DP-818)
**EYES**
aging, effects on pathological conditions, 17: 31861(R) (UCD-107 (p.44-9))
radiation effects, delayed, 17: 31861(R) (UCD-107(p.44-9))
radiation sickness effects on, in man, 17: 31978


# F


**FALLOUT**
content in atmosphere over Atlantic Ocean, March 8 to July 2, 1961, 17: 31844
distributions and effects of, survey, 17: 32276
fission product availability to plants from, 17: 31840
iodine-131 content in milk and people in Utah from, 17: 31848
manganese-54 content in Italian mollusks from, relation of, to age, 17: 31847
monitoring in Adriatic and Ligurian Seas by plankton beta activity, May 1961 to Nov. 1962, 17: 31845
monitoring in Alabama, 1961, 17: 32312
monitoring in France, May 1963, 17: 32289(R) (SCPRI(RM)V-1963))
monitoring in India, Oct. 19 and 30, 1961, 17: 32283 (AEET/AM/34)
monitoring in Japan, 1957 to 1962, 17: 32300
monitoring in New Zealand, 1963, 17: 32285(R) (DXRL-F8)
monitoring in Pittsburgh, Pa., 1963, 17: 32288 (NSEC-91)
monitoring of cerium-141 and -144 in, 17: 32298
monitoring of cesium-137 content in air, human body, and milk in Toronto, 1961–62, 17: 32297
monitoring of tritium in, during nuclear test moratorium, 17: 32758

particles of, in Osaka, Japan, microanalytical studies of, 17: 32302
protection against, afforded by structures, 17: 31804 (WT-1462)
radiation hazards from ingested iodine-131 and strontium-90, 17: 31839
strontium-90 content in man caused by food uptake, 1961, 17: 31846
tritium activity in precipitation, 17: 32281

**FAST REACTORS**
Doppler power coefficients of, use of theory of delayed supercritical excursions in determination of, 17: 33242 (KFK-153)

**FERMI FAST BREEDER REACTOR**
fuel element processing by electrolytic dissolution, 17: 32192(R) (DP-839)

**FERROMAGNETIC MATERIALS**
lattice interactions in Ising model for, long-range forces in, 17: 32764

**FFAG ACCELERATORS**
description of fixed-frequency helical-orbit, 17: 33128
design of 720-Mev proton, 17: 33112 (CONF-125-2)
magnet design for spiral-sector, 17: 33115 (CONF-125-5)
stability of spiral sector, betatron oscillation frequency dependence of, 17: 33111 (CONF-125-1)
use of 10-Bev high-intensity, as pion factory, 17: 33114 (CONF-125-4)

**FIBRINOGEN**
localization of iodine-131-labeled, in rat tumor, 17: 31820 (UR-630)
radiation effects on biological life of injected, tracer study, 17: 31916

**FIELD THEORY**
axioms in relativistic quantum, properties of, 17: 32760
characteristics of Lee-Yang charged-vector-meson, 17: 32959
conservation laws in relativistic, derivation of covariant, 17: 32805
description of high-energy interactions in, 17: 32952
dispersion relations for pseudoscalar-meson scattering, 17: 32951
eigenstates in soluble, effects of, 17: 32720 (NP-13004)
elementary particle model in, with nonzero angular momentum, 17: 32961
elementary particle weak interactions in unitary-symmetric, 17: 33233
equations solutions in, generalized cross-correlation quantities for, 17: 32761
formulation of local quantum, without u-v divergences, 17: 32807
infra-particles in, 17: 32925
isospin properties, 17: 32943
operators in, invariant parameterization of local, 17: 32953
Regge poles in, 17: 32910 (TID-7668(Sect.II))
scattering amplitudes in, Regge-pole effects on asymptotic, 17: 32957
scattering by potential wells in, Regge-pole effects on, 17: 32956
scattering phase-shift ambiguities in, 17: 33234
symmetries shared by strong and weak interactions, 17: 32936
symmetry groups in quantum, 17: 32800
unitary operators in quantum, theorems for construction of, 17: 32717(R) (NP-12996(p.29-35))
vector mesons as Regge poles in perturbation theory, 17: 32902 (EFINS-63-35)

**FILMS**
electric current in superconducting, electron depairing effects on, 17: 32839

**FILTERS**
development for use in radiation-resistant pneumatic power systems for space vehicles, 17: 32208(R) (GDC-63-140)

**FISSION**
neutron emission in, empirical formula for average number of, 17: 33016
theory of, liquid-drop model, 17: 33009(T) (UCRL-Trans-978)
thresholds for, determination by deuteron and gamma fission, 17: 33082

**FISSION PRODUCTS**
chemical reactions with soil, 17: 31816(R) (ORO-605)
deposition in fuel element cooling circuits, 17: 33322(R) (ORNL-3445 (p.138-98))
detection in alpha background, spark chamber properties for, 17: 32403 (UCRL-7169)
diffusion from fuel elements, research on, 17: 31795(R) (BNL-782 (p. 18-43))
diffusion from irradiated arc-cast and sintered uranium monocarbide, 17: 32691
diffusion in graphite, 17: 31798(R) (BNL-782(p.60-91))
diffusion in reactor fuel spheres, 17: 33321(R) (ORNL-3445(p.111-37))
diffusion in reactor fuel bodies, 17: 33322(R) (ORNL-3445(p.138-98))
diffusion of gaseous, from impregnated graphite shells of fuel elements, 17: 33273
energies and fine structure in californium-252, 17: 32995 (CONF-46-44)
energy loss by atomic collisions in semiconductor detectors, 17: 32792
fixation in ceramic microspheres, 17: 32327
metabolism in domestic animals and poultry, 17: 31816(R) (ORO-605)
neutron capture in second- and higher-generation, 17: 33325(R) (ORNL-3445(p.251-97))
plant metabolism, 17: 31840
release from ruptured fuel element in Plutonium Recycle Test Reactor, 17: 33369 (HW-75045)
separation from uranium dioxide–graphite dispersion fuels during nitric acid leach, 17: 32200
tracks in phosphate glass, preferential chemical dissolution for, 17: 32696
transport and deposition from gas streams in conduits, 17: 33243 (ORNL-3379)
yields from spontaneous fission of uranium-238, 17: 33109

**FISSION RECOILS**
kinetic energy of, as function of prompt gammas, 17: 33093
neutron emission by uranium-233, prompt, 17: 33089

**FISSIONABLE MATERIAL**
management by reactor operators, 17: 33269

**FLANGES**
seal for, vacuum testing of aluminum wire, 17: 33159(R) (ORNL-3472) (p.107-18))

**FLOWMETERS**
design for angle measurements in magnetohydrodynamics, 17: 32388
oscillations in, in PRTR, surge suppressors for, 17: 33368 (HW-70711 (Rev.))

**FLUID FLOW**
analysis of mercury- and oil-lubricated journal bearing, 17: 32249(R) (SY-5455-R)
bibliography on, 17: 32257
burnout conditions for boiling-water, in vertical round ducts, 17: 32243 (AE-114)
burnout conditions for boiling-water, in vertical round ducts, 17: 32242 (AE-113)
discontinuity in incompressible, stability of hydromagnetic Kelvin-Helmholtz, 17: 32774
heat transfer burnout in two-phase, 17: 33361
heat transfer in eccentric annulus, analysis of slug flow, 17: 32252
heat transfer in two-phase, development of loop for studying, 17: 32246(R) (GEAP-4251)
heat transfer in two-phase in round vertical tubes, 17: 32244 (EURAEC-637)
heat transfer to two-phase, in round vertical tubes with nonuniform axial power distribution, 17: 32245 (EURAEC-671)
hydrodynamics of two-phase, 17: 33361
in compact core of German FRJ-1, 17: 33372 (JÜL-125-RE)
magnetohydrodynamic, angle indicator for, 17: 32388
magnetohydrodynamic, insulator boundary layer effects in plasma jets, 17: 33201
measurement in gas-cooled and pebble-bed reactors, 17: 33326(R) (ORNL-3445(p.298-328))
of steam–water mixtures, effects of geometrical factors on dryout of, 17: 32260
oscillations of conducting, in magnetic field, 17: 32782
rates of, engineering drawings of system tracers for measuring, 17: 32379
void fraction measurements in two-phase, by gamma attenuation technique, 17: 32241(R) (ACNP-63020)

**FLUID FLOW (TURBULENT)**
bubble motion in, 17: 32250 (TID-19224)
heat transfer in, in annular passages, 17: 32255

**FLUID FUEL REACTORS**
control of suspension-type, by adding an electrolyte to the suspension, 17: 33295(P)
design of KEMA Suspension Test Reactor, 17: 33377

**FLUIDS**
magnetohydrodynamics of rotating, magnetic forces on, 17: 32874

sphere motion in conducting, transverse magnetic field effects on non-conducting, 17: 32783
sphere motion in conducting, transverse magnetic field effects on conducting and non-conducting, 17: 32784
**FLUORIDES**
effects of skeletal content, on deposition of strontium and calcium, tracer study, 17: 31841
**FLUORINE**
alpha reactions (α,n) with, neutron yields from, 17: 33017
alpha reactions (α,n) with, neutron yields from, 17: 33018
atomic wave functions for, with five parameters, 17: 32796
determination by alpha activation, 17: 32015
reactions with copper, zirconium boride, and zirconium carbide at high temperatures, kinetics of, 17: 32130
x-ray yields from electron bombardment of, K, 17: 32789
**FLUORINE ISOTOPES F-19**
alpha reactions (α,2α) at 22.5 Mev, angular correlations for, 17: 33097
carbon-13 reactions ($C^{13}$,γ) with, phosphorus-32 yield from, 17: 33060
energy levels of, negative parity states for, 17: 33092
proton scattering by, distributions from, 17: 33063
**FLUOROCARBONS**
purification of perfluorocyclohexane, chromatographic, 17: 31795(R) (BNL-782(p.18-43))
**FLUOROORGANIC COMPOUNDS**
radiation effects on, cosmic, 17: 32693
**FLUOROPHOTOMETERS**
design of double-beam, 17: 32364
**FLUORSPARS**
sintering of, material transport in, 17: 32535 (CONF-50-15)
**FOILS**
preparation of thin converter, by cathode sputtering, 17: 32769
preparation of thin, by cathode sputtering, 17: 32770
spectra of electron-irradiated, emission, 17: 32669 (ORNL-3450)
**FOLIC ACID**
effects of, on radiation effects on blood cells in chicks, 17: 31954
**FOOD**
insect control by gamma irradiation, 17: 32323
radiological monitoring in France, May 1963, 17: 32289(R) (SCPRI(RM)IV-1963))
radiopreservation in Germany, 17: 32324
strontium-90 content in, 1961, 17: 31846
**FOOD IRRADIATION FACILITIES**
use of mobile, for radiation processing of potatoes, 17: 32322
**FORESTS**
radiation effects on ecosystem and components, single and chronic gamma exposure, 17: 31854(R) (TID-19067)
**FORMALDEHYDE**
mutagenic effects in spermatogenesis of Drosophila, 17: 31892
**FORMIC ACID**
esters of, mass spectra of deuterated and normal, 17: 32160
**FRANCE**
fallout monitoring, May 1963, 17: 32289(R) (SCPRI(RM)IV-1963))
uranium technology development in, 17: 32183
**FREE RADICALS**
radioinduced, in liver and spleen lipids in rats, 17: 31927
**FREONS**
plasma jets of, characteristics of pinch, 17: 33196
**FRICTION**
analysis of mercury- and oil-lubricated journal bearing, 17: 32249(R) (SY-6455-R)
**FUEL CELLS**
properties of bromine–lead bromide, 17: 31794(R) (BNL-782(p.1-17))
**FURNACES**
design and availability of large-size, for heat treating metal assemblies, 17: 32207 (DMIC-Memo-167)
design and construction of continuous, for uranium dioxide sintering, 17: 32550
design of high-temperature x-ray-diffraction, with vacuum system, 17: 32488(R) (TID-19057)
**FUSED SALTS**
spectra of, bibliography and review on vibrational, 17: 32041 (ORNL-3413)

# G

**GADOLINIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
magnetization at 298°K, effects of magnetic field strength on, 17: 32646
**GADOLINIUM BORATES**
$GdBO_3$–$LaBO_3$, structural polymorphism of, 17: 32124
**GADOLINIUM BORIDES**
nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083
**GADOLINIUM CHLORIDES**
vapor pressure, 17: 32118
**GADOLINIUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**GADOLINIUM OXIDE COMPACTS**
fabrication and properties of sintered, 17: 33236(R) (ACNP-63022)
$Al_2O_3$–$Gd_2O_3$, fabrication and properties of sintered, 17: 33236(R) (ACNP-63022)
$Gd_2O_3$–$UO_2$, fabrication and properties of sintered, 17: 33236(R) (ACNP-63022)
**GADOLINIUM OXIDES**
phase transformations in, 17: 32058
shielding properties, 17: 33236(R) (ACNP-63022)
solubility in boiling water, 17: 32058
**GADOLINIUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**GADOLINIUM SULFIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**GADOLINIUM TELLURIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**GAGES**
survey of radiometric, 17: 32331
**GALAXIES**
radio emission halos of Milky Way and M31, model for, 17: 32848
radio sources in, identification with stellar objects, 17: 32847
**GALLIC ACID**
propyl ester, protective effects against radiation injuries in cells in tissue culture, 17: 31944
**GALLIUM**
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)
separation of, from bauxite by direct electrolysis and precipitation, economics of, 17: 32065
**GALLIUM ALLOYS**
As–Ga, thermal conductivity, 17: 32629
Ga–Sb, interband Faraday rotation in, 17: 32701 (AERE-R-4341)
Sb–Ga, thermal conductivity, 17: 32629
**GALLIUM ARSENIDES**
analysis for magnesium, silicon, and zinc, activation, 17: 32004
crystal structure of, frequencies of normal vibration modes in, 17: 32725(R) (PR-P-57(p.37-43))
Faraday rotation in, interband, 17: 32701 (AERE-R-4341)
radiation effects on diodes of, degradation of luminescence following, 17: 32672
**GAMMA RADIATION**
absorption and emission processes in nuclei, projection operator formalism for, 17: 33013
absorption by impurity nucleus in Bravais crystal, no-phonon and one-phonon cross sections for, 17: 33096
angular distribution analysis, calculation of coefficients for, 17: 33033

backscattering from concrete, factors for, 17: 33224
conversion factors for exposure to, flux to dose rate, 17: 31812
detection and measurements, techniques for, 17: 32456
detection and measurement of, increase of sensitivity of film method for, 17: 32457
detection and measurement in rocks and soils, 17: 32264 (UCRL-10636)
detectors for, developments, 17: 32915 (TID-7668(Sect.VII))
differential dose albedo on concrete, calculation of, 17: 33225
dose rate of radium, cavity chamber measurement of, 17: 32452
effects from ingested strontium-90 on spermatogenesis in dogs, 17: 31929
effects on blood agglutination and coagulation in dogs, 17: 31953
effects on bone marrow cells, 17: 31931
effects on chromosome aberrations in barley seeds, effects of intensity on, 17: 31902
effects on chromosomal rearrangement in spermatogenesis in monkeys, 17: 31950
effects on cytochromoxidase and succinic dehydrogenase activity in liver, nervous system, and skeleton in rabbits, fractionated, 17: 31979
effects on forest ecosystems and components, single and chronic exposure, 17: 31854(R) (TID-19067)
effects on grafted natural and synthetic fibers, 17: 32329
effects on metabolic processes in rats, effects of nutritional condition on, 17: 31838
effects on mice, protective effects of *S*-ethylisothiuronium against, 17: 31948
effects on mice, protective effects of drugs against, 17: 31966
effects on occurrence frequency of mutations in Drosophila, 17: 31936
effects on tyrosine oxidase activity, in rats, 17: 31884(T)
effects on viability and chromosome aberration in potato seeds, 17: 31938
emission in alpha reactions ($\alpha,\gamma$) with helium-3 at 0.42–5.80 Mev, energy dependence of transition branching ratios for, 17: 33103
emission in fission, fragment kinetic energy as function of, 17: 33093
energy measurement of, by external conversion method, 17: 32435
interactions with protons, cross sections for elastic, 17: 32912 (TID-7668(Sect.IV))
interactions with relativistic electrons, use for production of hard gamma beams, 17: 32960
internal conversion coefficients for K-shell, Coulomb field effects on threshold, 17: 33047
lethal effects on Salmonella bacteria species in eggs, 17: 31889
mutational response patters to, in *Drosophila melanogaster*, 17: 31894
polarization in cascades of, development of angular-correlation polarimeter for measuring, 17: 32400 (KFK-129)
protection against, by chemical protective substances, 17: 31940
radiation effects on incidence of chromosomal aberrations in mice, 17: 31958
reactions on nuclei, mesons ($\pi^0$) from, 17: 33073
reactions on nuclei, distributions of neutrons from, 17: 33074
reactions on plutonium and uranium isotopes, fission from, 17: 33082
reactions with metals, electron emission in, 17: 32726(R) (PR-P-57(p.44-68))
reactions with nuclei, resonance effects in, 17: 33034
reactions with oxygen-16, study of giant resonance in, by electron inelastic scattering, 17: 33052
scattering by aluminum-27, resonant, 17: 32725(R) (PR-P-57(p.37-43))
scattering by nuclei, excited-state lifetimes from resonant, 17: 33076
scattering of beam from point source in aluminum, concrete, iron, and lead, 17: 32923
skin surface ionization reactions, 17: 31871
spectra in sea waters, from radioactive isotopes, 17: 32718(R) (NP-12996(p.36-7))
use in measuring vapor volume fraction, 17: 32241(R) (ACNP-63020)

**GAMMA SOURCES**

description of near-monochromatic hard, using Compton effect, 17: 32960
disintegration rate of cesium-137, tracer studies of absolute, 17: 32319 (AE-112)
dose field calculation for, method for, 17: 32299

**GAMMA SPECTRA**

analysis of, computer uses for, 17: 32481
display and interpretation of, for neutron activation analysis, 17: 32010

**GAMMA SPECTROMETERS**

description of proposed triple-coincidence, for high-energy gamma rays, 17: 32431
design of, engineering drawings for, 17: 32377
development of scintillator, using beta-gamma coincidence, 17: 32399 (HW-SA-2932)
drift control in, device for, 17: 32466(P)

**GAMMA SPECTROSCOPY**

computer uses in, 17: 32481
performance of external-conversion methods for, 17: 32435
use in reactor fuel element analysis, 17: 32012

**GAS COOLED REACTORS**

coolant circuit breach detector and isolator, 17: 33292(P)
coolant flow restrictor design for vertical coolant channels, 17: 33291(P)
coolants for, comparison of, 17: 33325(R) (ORNL-3445(p.251-97))
design, 17: 33361
design of unmoderated package-power, 17: 33313 (IDO-28584(Add.1))
design of 750-Mw(e) ORNL, GCR-3, 17: 33305 (CONF-39-49)
development, 17: 33316(R) (ORNL-3445)
development of, for power plants, 17: 33304 (CONF-39-33)
fission-product transport and deposition from gas streams in, 17: 33243 (ORNL-3379)
fluid flow and heat transfer parameters for pebble-bed, 17: 33325(R) (ORNL-3445(p.251-97))
fluid flow and heat transfer in pebble-bed, 17: 33326(R) (ORNL-3445 (p.298-328))
fuel cycle costs for pebble-bed, 17: 33325(R) (ORNL-3445(p.251-97))
fuel-element design to prevent vibration in channels, 17: 33284(P)
fuel-element design to prevent vibration in channels, 17: 33285(P)
fuel-element design to prevent vibration in channels, 17: 33286(P)
fuel management procedures for AVR, 17: 33325(R) (ORNL-3445(p.251-97))
power cycle development for GCR-4, 17: 33325(R) (ORNL-3445(p.251-97))
simulation of graphite-moderated, 17: 33268

**GAS FLOW**

fission-product transport by, 17: 33243 (ORNL-3379)

**GASEOUS DIFFUSION PROCESS**

equipment for, factors affecting design criteria for, 17: 32467 (CONF-8-5)

**GASES**

diffusion of, effects of mixing ratio on coefficient of, 17: 32052(T) (AEC-tr-5938)
distributions in disturbed, fluctuating, 17: 32811
equation of state of hard-sphere, hyper-chains, 17: 32778
oscillations and convective instability of, nonradial, 17: 32743
radioactivity of beta-emitting, development of ionization chamber for measuring, 17: 32398 (CEA-2215)
shock waves in, production by electric sparks, 17: 32801

**GASTROINTESTINAL TRACT**

radiosensitivity of various segments of, 17: 31896

**GEIGER-MUELLER TUBES**

use as switches in coincidence circuits, 17: 32425

**GENETICS**

effects of chemical mutagens and radiation on seeds, bibliography, 17: 31869
formal and physiological, of ascospore color in Aspergillus, 17: 31883
radiation effects on seed, environmental factors in, 17: 31951

**GEOCHEMISTRY**

bibliography on research on uranium, 17: 31810

**GEOLOGY**

book: *Radiogenic Argon in Minerals and Rock*, 17: 32278
variability of, in Switzerland used to study terrestrial radiation dose, 17: 31829

**GEOMAGNETIC FIELDS**

boundary of outer, mapping of, 17: 32862
deformation during magnetic storms, 17: 32864
electric ring currents in, guiding-center approximation for, 17: 32863
electron intensity decay rate and spatial distribution from high-altitude explosions, trapped, 17: 32279
interactions with trapped particles, vlf radiation from, 17: 32868
magnetopause in, nature and processes of, 17: 32876
production by dynamo action of Earth's core, 17: 32874

properties, 17: 32879
trapping from high-altitude explosions by, 17: 32845 (UCRL-7309(Rev.I))
variation in, correlation with polar-cap aurorae, 17: 32865
variations in, at geomagnetically conjugate points, 17: 32867
**GEOMAGNETIC STORMS**
correlation with polar-cap aurorae, 17: 32865
electric ring currents in, guiding-center approximation for, 17: 32863
magnetic pulsations at geomagnetically conjugate points, 17: 32867
perturbative effects on geomagnetic fields, 17: 32864
ring current effects on main phase of, 17: 32878
**GERMANIUM**
Faraday rotation in, interband, 17: 32701 (AERE-R-4341)
radiation effects on properties of, neutron, 17: 32694
wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445 (p.199-217))
**GERMANIUM ALLOYS**
Cu–Ge–Mn, paramagnetism and valency in, 17: 32561 (AE-111)
**GERMANIUM FILMS**
electron reactions with, emission spectra from, 17: 32669 (ORNL-3450)
**GERMANIUM ISOTOPES Ge-74**
alpha, deuteron, proton, and triton reactions on, 17: 33075
**GERMANIUM ISOTOPES Ge-76**
alpha, deuteron, proton, and triton reactions on, 17: 33075
**GERMANIUM JUNCTIONS**
performance of p-n, in logarithmic amplifiers, 17: 32349
radiation effects on, neutron, 17: 32680
**GLASS**
bibliography on composites, 17: 32482 (AD-408618)
decontamination of, using ultrasonics, 17: 32304
development of optic fibers of, for fluoroscopy, 17: 31822
electrical discharge in irradiated shielding, 17: 31796(R) (BNL-782 (p.44-50))
electrochemical properties of barium oxide–lanthanum oxide–silicon oxide, 17: 32097
electrode properties of cesium oxide–lanthanum oxide–lithium oxide–silicon oxide, 17: 32096
preparation of crystals of, by zone melting at 2320 to 3800°K, 17: 32590
properties of alumino-silicate, for uranium dioxide, 17: 32506
radiation effects on electrostatic charges in tubes of, 17: 32687
radioisduced polymer film formation on, 17: 32695
radiosterilization of ampules of, containing medicine, 17: 32675
**GLOBULIN**
gamma, radiation effects on blood content of natural and injected, in rabbits, 17: 31972
**GLOW DISCHARGES**
positive column instability in magnetic field, 17: 33161 (UCRL-10698)
**GLYCINE**
effects on ammonia and nitrogen content in rabbit blood during radiation sickness, 17: 31975
spectrum of deuterated and undeuterated, vibrational, 17: 32146
**GLYCOLS**
radiation effects on, cosmic, 17: 32693
**GLYCOLYSIS**
radioinduced inhibition of, in Ehrlich ascites carcinoma, labile phase of, 17: 31959
**GOLD**
electron emission by, gamma-induced, 17: 32726(R) (PR-P-57(p.44-68))
gamma reactions on, distributions of neutrons from, 17: 33074
neutron capture cross section at 24 Mev, 17: 33005 (ORNL-TM-636)
wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445 (p.199-217))
**GOLD COATINGS**
deposition and stability of, on beryllium, 17: 32574 (PWA-2184)
**GOLD ISOTOPES Au-196**
production in lithium-6 reactions with gold-197 at 15–40 Mev, excitation functions for, 17: 33038
**GOLD ISOTOPES Au-197**
lithium-6 reactions at 15–40 Mev, excitation functions for nuclei $196 \leq A \leq 200$ production in, 17: 33038
proton reactions (p,n) on, cross sections for, 17: 33072
**GOLD ISOTOPES Au-198**
beta spectra measurements by solid-state detectors, 17: 32421
conversion electron-gamma coincidence spectra, 17: 32421
incorporation into sand, 17: 31982
production in lithium-6 reactions with gold-197 at 15–40 Mev, excitation functions for, 17: 33038
use in medicine, bibliography on, 17: 31814 (KFK-143)
**GONADS**
radiation effects on ovaries, delayed, 17: 31866(R) (UCD-107(p.112-28))
radiation effects of fast neutrons and x rays on, in mice, 17: 31891
radiation effects on, from ingested strontium-90 in dogs, 17: 31929
**GRANITES**
mass spectrum of secondary ions from, 17: 32389
**GRAPHITE**
ash content of electro-, effects of graphitization-temperature and time on, 17: 32655
brazing of, to itself and metals, feasibility of, 17: 32547
development and properties as reactor moderator material, 17: 33324(R) (ORNL-3445(p.218-50))
fission gas release from impregnated shells of, containing fuel elements, 17: 33273
graphitization of pyrolytic, effects of applied stress on, 17: 32649
impregnation with silicon *in vacuo*, 17: 32554
oxidation of, effects of catalytic impurities on, 17: 32128
physical properties at high pressures and temperatures, 17: 32641
properties of, radiation effects on gas permeability and mechanical, 17: 33253
properties of, research on chemical and physical, 17: 31795(R) (BNL-782(p.18-43))
radiation effects of massive neutron exposure on distortion of, 17: 32667 (HW-SA-2926)
radiation effects on Young's modulus of pile, electron, 17: 32685
radiation effects on oxidation of, 17: 32688
radiation effects on, neutron, 17: 31798(R) (BNL-782(p.60-91))
solvent properties for iodine, 17: 31798(R) (BNL-782(p.60-91))
graphite–SiC, production of high thermal resistance, 17: 32554
**GRAPHITE COATINGS**
deposition of, on reactor fuel particles, development of production scale procedure for, 17: 33279
**GRAPHITE MODERATED REACTORS**
simulation of gas-cooled, 17: 33268
**GRAPHITE SYSTEMS**
neutron bucklings for, critical, 17: 31794(R) (BNL-782(p.1-17))
**GRAVITATION**
conservation laws in theory of, derivation of covariant, 17: 32805
fields of, Weyl tensor continuity in, 17: 32737
**GROUND WATERS**
analysis for radium-226 and radon-222, equipment and method for, 17: 32312

# H

**HAFNIUM**
alloying effects on mechanical properties of aluminum alloys, 17: 32608
determination in meteorites, rock, and sediments, neutron activation, 17: 31986 (TID-19179)
diffusion of oxygen in, at 800 and 950°C, 17: 32601
preparation by electrolysis, 17: 32514(P)
**HAFNIUM CARBIDES**
sintering without binder, pressure, 17: 32583
HfC–UC, carbon-stable regions in, 17: 32617
**HAFNIUM COMPLEXES**
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068
**HAFNIUM ISOTOPES Hf-177**
internal conversion line intensity ratio for, anomalous L., 17: 32724(R) (PR-P-57(p.21-36))
**HAFNIUM OXIDES**
preparation of hydrogen-containing, relation to metal oxide bronzes, 17: 32088
**HAFNIUM SYSTEMS**
Hf–O, crystal structure and thermodynamic properties at 0 to 25 at.% oxygen, 17: 32630
**HAIR**

radiation effects on pigmentation of, electron and heavy ion, 17: 31882
uptake of tyrosine by rat, radioautography of different ways of, 17: 31834

**HALDEN BOILING REACTOR**
operation results of Core I, 17: 33347

**HALLAM POWER REACTOR**
fuel element processing by electrolytic dissolution, 17: 32192(R) (DP-839)
stress analysis of loading-face shield in, 17: 33251

**HANDBOOKS AND MANUALS**
for users of the ORNL Relativistic Isochronous Cyclotron, 17: 33118 (ORNL-TM-643)
on nuclear safety, 17: 32293 (Y-1272)
on radiochemical analysis of environmental samples, 17: 32282 (AECL-1745)
on radioisotope preparation, properties, and uses, 17: 32174
on test reactor operation, 17: 33371 (IDO-16871-1)
Physical Constants Testing Reactor manual, 17: 33367 (HW-69714)

**HANFORD PRODUCTION REACTORS (N)**
connector couplings in, performance of spherical nut-clamp seating geometries in, 17: 33362 (HW-71229)
fission product confinement system for, 17: 33363 (HW-SA-2891(Rev.))

**HARWELL SYNCHROTRON**
efficiency increases in, by extension of duty cycle, 17: 33131
efficiency increases in, by extension of duty cycle, 17: 33132

**HASTELLOY X**
corrosion, oxidation, and strength of, comparison of nickel–thorium oxide system with, 17: 32501

**HAYNES 25 ALLOY**
corrosion, oxidation, and strength of, comparison of nickel–thorium oxide system with, 17: 32501

**HEALTH PHYSICS**
laboratory test chamber for studying air-borne materials, 17: 32292 (UR-629)
manual on radiochemical analysis of environmental samples, 17: 32282 (AECL-1745)
research programs of UKAEA, ninth annual summary, 17: 31800(R) (NP-12981)
state program in Kentucky, one year's experience, 17: 32316

**HEART**
development of equipment and techniques for radiocardiography studies, 17: 31818 (TID-19168)
development of equipment and techniques for radiocardiography studies, 17: 31819(R) (TID-19173)

**HEART DISEASES**
in irradiated and aging dogs, 17: 31862(R) (UCD-107(p.50-73))

**HEAT-RESISTING ALLOYS**
analysis for cerium, photometric, 17: 32021

**HEAT TRANSFER**
bibliography on, 17: 32257
burnout conditions for flow of boiling water in vertical round ducts, 17: 32242 (AE-113)
burnout conditions for flow of boiling water in vertical round ducts, 17: 32243 (AE-114)
burnout in two-phase flow, 17: 33361
by carbon dioxide in laminar free convection near the critical point, 17: 32258
by organic liquids, 17: 32254
effects of geometrical factors on dryout of high-quality steam–water mixtures flowing in a vertically heated annulus, 17: 32260
in cylindrical body, computer program for calculation of, 17: 32248 (RCN-16)
in fluid flow in eccentric annulus, analysis of slug flow, 17: 32252
in forced convection of fluids between parallel plates, 17: 32256
in steam–water flow in round vertical tubes, 17: 32244 (EURAEC-637)
in steam–water flow in round vertical tubes with nonuniform axial power distribution, 17: 32245 (EURAEC-671)
in transition boiling, development of equipment for studying, 17: 32247(R) (GEAP-4307)
in turbulent flows through annular passages, 17: 32255
in two-phase flow, development of loop for studying, 17: 32246(R) (GEAP-4251)
measurement in gas-cooled and pebble-bed reactors, 17: 33326(R) (ORNL-3445(p.3445(p.298-328))
research at Brookhaven, 17: 31795(R) (BNL-782(p.18-43))
to stainless-steel tube from flowing sodium, 17: 32253
unsteady, in combined free and forced convection in tubes with constant axial temperature gradient at wall, 17: 32261

**HEAT TRANSFER SYSTEMS**
design and development for two-phase flow studies, 17: 32246(R) (GEAP-4251)
design and development for transition boiling studies, 17: 32247(R) (GEAP-4207)
design for measuring void fractions, 17: 32241(R) (ACNP-63020)

**HEAT TREATMENT**
of metal assemblies, design and availability of large-size furnaces for, 17: 32207 (DMIC-Memo-167)

**HEAVY WATER REACTORS**
design description of Swedish power-producing, 17: 33350

**HELIUM**
atomic wave functions for, with five parameters, 17: 32796
corrosive and structural effects on chromium–molybdenum carbon steel and type 316 stainless steel at 70, 1100, and 1200°F, 17: 32571(R) (MSAR-63-105)
crystal structure of, isotopic effects on unit-cell volumes, 17: 32106
determination in in-pile loops, equipment for chromatographic, 17: 33327(R) (ORNL-3445(p.329-46))
determination in volume range $10^{-4}$ to $10^{-8}$ cc using hot-wire manometer, 17: 31987(T) (AAEC/Trans-14)
electric conductivity of cesium-seeded plasma of, near thermal equilibrium, 17: 33216
electric discharge in, positive column instability in, 17: 33161 (UCRL-10698)
flow of liquid II, entropy production and heat flow in narrow-channel, 17: 32740
helium ion interactions at 0.133 to 1 Mev, free electron and ion production in, 17: 32731 (TID-19137)
ionization by protons, cross sections for, 17: 32790
Landau excitation curve for, 17: 32725(R) (PR-P-57(p.37-43))
level indicator for liquid, 17: 32365
meson ($\mu$) capture by, mesic atoms from, 17: 33080
performance of lithium seeded plasma of, in magnetohydrodynamic cells, 17: 32817
plasma jets of, characteristics of pinch, 17: 33196
plasma jets of, electric current and field distribution in, 17: 33203
plasma jets of, performance of Hall current, 17: 33205
plasma jets of, performance of crossed-field, 17: 32835
precipitation of, during annealing of cold-worked and irradiated aluminum-lithium alloys, 17: 32603
reactions of carbon dioxide-contaminated, with graphite, 17: 33324(R) (ORNL-3445(p.218-50))
scattering on helium atoms at 2 kev, non-adiabatic effects in, 17: 32833
turbulence propagation in liquid, after application of a heat current, 17: 32752

**HELIUM IONS**
interactions with light elements and compounds, free electron and ion production in, 17: 32731 (TID-19137)
production in cation beam reactions with hydrogen, 17: 32838
reactions with atoms, ionization cross sections for, 17: 32771

**HELIUM ISOTOPES**
$He^3$–$He^4$, state diagrams of, 17: 32802

**HELIUM ISOTOPES He-3**
alpha reactions ($\alpha$,$\gamma$) at 0.42–5.80 Mev, energy dependence of capture cross sections and transition branching ratios in, 17: 33103
alpha reactions ($\alpha$,$\gamma$) with, direct-capture model for, 17: 33104
interactions with alpha particles at 0 to 20 Mev, 17: 32993 (BNL-6955)
phase transitions in solid, interpretation of, 17: 32776
production by cosmic proton reactions on planetesimals, 17: 32866
production in high-energy proton reactions with nuclear emulsion, 17: 33091
reactions ($He^3$,$\alpha$) and ($He^3$,p) with beryllium-9 at 2.0 Mev, angular distributions in, 17: 33054
reactions with carbon-12 in acetylene, 17: 32153 (JEN-119-DF/136)
virial coefficients for, high-temperature quantum corrections to,

17: 32773
**HELIUM ISOTOPES He-4**
melting curve of, direct measurement of the minimum in, 17: 32780
phase transitions in solid, interpretation of, 17: 32776
virial coefficients for, high-temperature quantum corrections to, 17: 32773
**HELIUM SYSTEMS**
Cs–He, effects of magnetic fields on electric conductivity of, 17: 32814
He–$O_2$, free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
**HEMATOPOIETIC SYSTEM**
formation of lymph cells, tracer study, 17: 31852 (BNL-7137)
radiation sickness effects on rabbit, effects of phenylhydrazine on, 17: 31974
**HETEROGENEOUS REACTORS**
design and development of, with nuclear superheating, review of, 17: 33336
**HIGH-ALTITUDE EXPLOSIONS**
electron flux and decay of artificial radiation belt following Starfish burst, 17: 32860
electron intensity decay rate and spatial distribution from, geomagnetically trapped, 17: 32279
nuclear, mass motion in, 17: 31803 (UCRL-7224(Rev.II))
**HIGH ENERGY INJECTION DEVICES**
development, 17: 32745
development of DCX-1 and -2, 17: 33152(R) (ORNL-3472(p.9-23))
developments at ORNL, 17: 33151(R) (ORNL-3472(p.1-8))
performance of DCX-2, 17: 33157(R) (ORNL-3472(p.75-83))
stabilization of DCX-1, 17: 33157(R) (ORNL-3472(p.75-83))
**HOLMIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
**HOLMIUM ALLOYS**
Ho–Mo–Zr, magnetic properties of, 17: 32651
Ho–Zr, magnetic properties of, 17: 32651
**HOLMIUM BORATES**
$HoBO_3$–$LaBO_3$, structural polymorphism of, 17: 32124
**HOLMIUM CHLORIDES**
vapor pressure, 17: 32118
**HOLMIUM NITRIDES**
electric and optical properties, 17: 32652
properties of, electric and magnetic, 17: 32081
**HOLMIUM SELENIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**HOLMIUM SULFIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**HOLMIUM TELLURIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**HOMOGENEOUS REACTORS**
control of suspension-type, by adding an electrolyte to the suspension, 17: 33295(P)
operation at vapor pressure of core solution, 17: 33297(P)
recombiner for use with, 17: 33297(P)
**HUNGARY**
bibliography of publications of Inst. of Nuclear Research of Hungarian Academy of Sciences, 17: 31810
**HYDRAZINE, PHENYL-**
effects of, on hematopoietic system in rabbits during radiation sickness, 17: 31974
**HYDRAZINES**
α,α-diphenyl-β-picryl-, electron paramagnetic resonance spectrum of, 17: 32756
**HYDRAZYL, DIPHENYLPICRYL-**
radiation effects on electron paramagnetic-resonance absorption spectrum of, 17: 32756
**HYDRIDES**
classification according to valence electrons, 17: 32108
**HYDROAROMATIC COMPOUNDS**
radiation effects on, cosmic, 17: 32693
**HYDROCARBONS**
analysis for carbon-hydrogen ratio, engineering drawings of analyzer for, 17: 32382
radiation chemistry of, review of, 17: 32170
**HYDROCHLORIC ACID**
solvent properties for aluminum, iron, thorium, and uranium, 17: 32194(R) (TID-19068)
**HYDRODYNAMICS**
calculations for mercury- and oil-lubricated journal bearings, 17: 32249(R) (SY-5455-R)
of two-phase flow, 17: 33361
**HYDROFLUORIC ACID**
reactions with nitrosyl chlorides, NOF - 3.1 HF production in, 17: 31795(R) (BNL-782(p.18-43))
$Al(NO_3)_3$–HF–$HNO_3$, corrosive effects on type 304L stainless steel and zirconium, 17: 32192(R) (DP-839)
HF–$HNO_3$, corrosive effects on stainless steel containing boron-10, 17: 32517 (RFP-307)
**HYDROGEN**
absorption by cerium–magnesium alloys, 17: 32643
accumulation and injection of high energy atoms and molecular ions of, in magnetic mirror systems, 17: 33187
additive effects on production of μ-mesic helium, 17: 33080
atomic wave functions for, with five parameters, 17: 32796
boiling in, liquid-solid interface effects on nucleation characteristics in, 17: 32828
cation beam reactions with, anion production ion, 17: 32838
corrosion embrittlement effects on niobium-zirconium alloys, 17: 32525
determination of ratio to carbon in hydrocarbons, engineering drawings of analyzer for, 17: 32382
dissociation and ionization of, 17: 33155(R) (ORNL-3472(p.56-69))
dissociation of, proton trapping by Lorentz, 17: 33151(R) (ORNL-3472 (p.1-8))
electric discharge in, positive column instability in, 17: 33161 (UCRL-10698)
electron avalanche growth in, visible discharge in, 17: 32786
electron capture by protons in, cross sections for, 17: 33061
electron scattering on atomic, resonance energies for, 17: 32788
embrittlement and permeation of SAE 4130 steel by, 17: 32521
embrittlement effects on SAE 4130 steel, effects of gas content on, 17: 32522
heat of desorption, 17: 33159(R) (ORNL-3472(p.107-18))
helium ion interactions at 0.133 to 1 Mev, free electron and ion production in, 17: 32731 (TID-19137)
hydrogen-ion reactions with, ionization cross sections for, 17: 32771
ion beam reactions with, anion production in, 17: 32723(R) (PR-P-57 (p.5-20))
ionization by protons, cross sections for, 17: 32790
isotopic exchange between liquid ammonia and, on heterogeneous catalysts, 17: 32078
meson (μ) atoms and molecules in, production rates for, 17: 33003 (NEVIS-117)
meson ($\mu^-$) capture by liquid, meson (μ)-electron universality in, 17: 33002 (NEVIS-116)
meson ($\pi^-$) capture at rest by, Panofsky ratio for, 17: 32947
performance of cesium seeded plasma of, in magnetohydrodynamic cells, 17: 32817
plasma jets of, characteristics of pinch, 17: 33196
plasma jets of, performance of coaxial, 17: 33207
proton reactions with atomic and molecular, charge exchange in, 17: 32837
proton scattering by, two-electron exchange cross sections in, 17: 33077
reactions with atoms, ionization cross sections for, 17: 32771
recombination with oxygen in water-boiler reactors, catalytic, 17: 33297(P)
shock wave fronts in atomic, effects of Lyman continuum radiation on structure of, 17: 32744
shock waves in, production by electric sparks, 17: 32801
solubility of, in iron, effects of cerium, lanthanum, neodymium, and praseodymium on, 17: 32597
spectra of, in auroral patches, 17: 32861
stability of solid plutonium(IV) oxide–uranium(IV) oxide, 17: 32634

triton reactions (t,n) with, use as neutron source, 17: 33035
uptake by zirconium alloys during steam and water corrosion, 17: 32519
viscosity of gaseous and liquid, at temperatures up to 5000°K, 17: 32066
wave functions for molecular, based on 1s-type orbitals, 17: 32767

**HYDROGEN COMPOUNDS**
neutron scattering by, 17: 32986

**HYDROGEN IONS**
dissociation of molecular, by electric fields, 17: 32732(R) (TID-19169)
injection into DCX-2, 17: 33156(R) (ORNL-3472(p.70-4))
production in hydrogen ion dissociation in hydrogen and water vapor, 17: 33155(R) (ORNL-3472(p.56-69))
reactions of molecular, with atoms, ionization cross sections for, 17: 32771
wave functions for molecular, based on 1s-type orbitals, 17: 32767

**HYDROGEN ISOTOPES H-4**
binding energy and radial function potential, 17: 32930

**HYDROGEN SULFIDES**
sulfur-35 exchange between sulfide crystals and, 17: 32138

**HYDROMAGNETIC WAVES**
dispersion relations for plasma oscillations, 17: 33189
propagation through cylindrical conducting fluid, skin effect in, 17: 32775

**HYPERFRAGMENTS**
decay of Λ-, analysis of nonmesic, 17: 32903 (EFINS-63-39)
interactions of, strong and weak, 17: 32900 (EFINS-63-29)
research on, future, 17: 32901 (EFINS-63-32)

**HYPERONS**
parity and spin of resonance-state, 17: 32941
production of resonance-state, in nucleon-photon interactions, 17: 32966
research on, future, 17: 32901 (EFINS-63-32)

**HYPERONS (Λ)**
interactions of bound, strong and weak, 17: 32900 (EFINS-63-29)
interactions with nucleons, structure of weak, 17: 32903 (EFINS-63-39)
parity and spin of, 17: 32941

**HYPERONS ($\Lambda^0$)**
photoproduction on protons, polarization in, 17: 32912 (TID-7668(Sect. IV))

**HYPERONS (Σ)**
parity and spin of, 17: 32941

**HYPERONS ($\Sigma^-$)**
mass, 17: 32918 (UCRL-10897)

**HYPERONS ($\Sigma^0$)**
mass, 17: 32918 (UCRL-10897)

**HYPERONS (Ξ)**
parity and spin of, 17: 32941
production in meson (K )-proton interactions at 2.3 Bev/c, 17: 32898 (BNL-7105)

**HYPERONS ($\Xi^-$)**
production in meson ($\pi^-$) interactions with nucleons at 6.8 and 8.0 Bev/c, cross sections for, 17: 32945

**HYPOCHLORITES**
use in carbonate leach process for uranium ores, 17: 32188(P)


# I


**ICE**
neutron slowing down in, at 90 and 273°K, 17: 32989

**IMMUNITY**
effects of x radiation and pertussis sensitization on adrenal gland activity, 17: 31910
radiation effects on response to antigen, 17: 31914
radiation effects on reactions to transplanted tumors, 17: 31915
radiation effects on sensitivity to toxins, 17: 31921
radiation sickness effects on, epidemiology of, 17: 31977
thorium oxide effects on sensitivity to toxin, in monkeys, 17: 31918

**IN-PILE LOOPS**
development and operation of GCR-ORR No. 2, 17: 33327(R) (ORNL-3445(p.329-46))
operation in NRX Reactor for organic-coolant studies, 17: 32662 (CRFD-1132)

**INDIA**
fallout monitoring in, Oct. 19 and 30, 1961, 17: 32283 (AEET/AM/34)

**INDIAN POINT POWER REACTOR**
design review, 17: 33361
operating experience, 17: 33342
operating experience and description of, 17: 33357

**INDIUM**
neutron capture cross section at 24 Mev, 17: 33005 (ORNL-TM-636)
neutron radiative capture in, optical model for cross sections of, 17: 33048
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)

**INDIUM ALLOYS**
As–In, thermal conductivity, 17: 32629
In–Hg, electrode processes on, in perchlorate solution, 17: 32642
In–Sb, interband Faraday rotation in, 17: 32701 (AERE-R-4341)

**INDIUM ARSENIDES**
Faraday rotation in, interband, 17: 32701 (AERE-R-4341)

**INDIUM COMPLEXES**
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068

**INDOLES, 3–(2-AMINOETHYL)–**
protective effects against radiation damage in mice, correlation of dose with, 17: 31966

**5-INDOLOL, 3-(2-AMINOETHYL)-**
reaction of normal and malignant tissues to, 17: 31939

**INDUSTRIAL HYGIENE**
for uranium ore processing plants, 17: 32311

**INFECTIONS**
radiation sickness effects on resistance to, epidemiology of, 17: 31977

**INFRARED RADIATION**
absorption and transmission by semiconductors, effects of free carrier absorption on, 17: 32729 (SCR-636)

**INFRARED SPECTROMETERS**
design and precision of Ebert-type, 17: 32341 (TID-19175)

**INOR-8**
mechanical properties of cast, 17: 32573 (ORNL-TM-607)

**INSECTS**
mutations induced by x rays and chemical mutagens in the moth Ephestia, 17: 31856(R) (TID-19166)
radiosterilization of flour and cereal, 17: 32323

**INSTRUMENTATION**
for nuclear rockets, review of, 17: 33389

**INSTRUMENTS**
design of flying-spot film measuring machine employing crossed glass fibers, 17: 32332 (BNL-6878)
operation of analog-to-digital converter, errors and precisions in, 17: 32408

**INSULIN**
protective effects against radiation injury of gastrointestinal tract, 17: 31896

**INTERFEROMETERS**
development of, for use with optical pumping cells, 17: 32047 (TID-19198)
use of Fabry-Perot, for ion thermometry in PIG discharge, 17: 33168

**INTERMEDIATE REACTORS**
neutron physics of, 17: 32990

**INTERNATIONAL ATOMIC ENERGY AGENCY**
information program on design and operating experience of power reactors, 17: 33340

**INTESTINE**
radiation effects on DNA, nucleoproteins, and RNA content in, in chicken, 17: 31955

**INULIN**
chemical and physiological properties of natural and labeled, 17: 31920

**IODIDE IONS**
formation from iodine and iodide ions in nitrobenzene, constants of, 17: 31796(R) (BNL-782(p.44-50))

**IODINE**
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
metabolism in domestic animals, tracer study, 17: 31816(R) (ORO-605)
neutron capture cross section at 24 Mev, 17: 33005 (ORNL-TM-636)
sorption by graphite, 17: 31798(R) (BNL-782(p.60-91))

**IODINE ISOTOPES I-127**
beta-gamma correlations in, coefficients for, 17: 32724(R) (PR-P-57 (p.21-36))
**IODINE ISOTOPES I-129**
energy levels of, half life of first excited-state, 17: 33041
**IODINE ISOTOPES I-131**
content in bovine thyroid glands, collected in Alabama, 1961, 17: 32313
content in milk and people in Utah from 1962 fallout, 17: 31848
deposition in thyroid from milk and non-milk sources, 17: 31849
determination in environmental samples, radiochemical, 17: 32282 (AECL-1745)
diffusion from irradiated uranium when heated in air, 17: 32287 (LF-9)
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
dispersion, half life on vegetation, and incorporation into food chain after stack release, 17: 32284 (DPSPU-63-30-26B)
from fallout, biological availability for human populations, 17: 31839
localization of, in rat tumors, effects of fibrinogen on, 17: 31820 (UR-630)
production by neutron irradiation of tellurium, 17: 32180(P)
release from reactor fuel spheres, 17: 33321(R) (ORNL-3445(p.111-37))
use as tracer in pulp and paper research, 17: 32328
**IODINE ISOTOPES I-133**
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
**IODINE ISOTOPES I-135**
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
**ION BEAMS**
acceleration of, effects of cyclotron parameters on phase and duration in, 17: 33124
effects on hair pigmentation, 17: 31882
focusing of, image-forming characteristics of periodic field lenses for, 17: 32369
production of intense shaped, design of gun for, 17: 32841(P)
production of pulsed, 17: 32840(P)
use in metallographic etching, 17: 32505
**ION COMPLEXES**
use of, in efficiency tracing method for standardization of beta emitters, 17: 32413
**ION EXCHANGE PROCESSES**
characteristics of cation, using acetone as solvent, 17: 32092
**ION EXCHANGERS**
description of units for large-scale separations in fuel processing, 17: 32198
development for absorption of fission products from waste solutions, 17: 33408
development of, for selective adsorption of bismuth, 17: 32195(T) (KFK-tr-130)
**ION SOURCES**
description of hot-cathode filamentless, for cyclotrons, 17: 33133
design and performance for mass spectrography of solids, 17: 32389
design of gun to produce intense shaped beams, 17: 32841(P)
design of pulsed, 17: 32840(P)
development at ORNL, 17: 33156(R) (ORNL-3472(p.70-4))
development of cesium, 17: 32825
development of controlled-growth colloidal, for propulsion systems, 17: 32217
pressure measurement in mass spectrometers at very high pressures, 17: 32387
**IONIZATION CHAMBERS**
design for use with gas chromatograph, engineering drawings for, 17: 32381
design of pocket dosimeter with magnetically actuated charging means, 17: 32461(P)
development for measuring activity of beta-emitting gases, 17: 32398 (CEA-2215)
performance, during low field strength operation, effect of columnar ionization of inert gases, 17: 32290(R) (TID-19111)
properties for gamma dosimetry, 17: 32452
properties of, for measurement of atmospheric natural radioactivity, 17: 32280
use in gas chromatography, 17: 32384
**IONOSPHERE**
charge neutralization in, design of equipment for measuring, 17: 32844(R) (ARF-A218-12)
cosmic-noise absorption and enhancements in, similarity of solar flare effects on, 17: 32857
electron density profile in F2 layer of, effects of temperature changes on, 17: 32870
electron energy distribution functions in, 17: 32882
ionization drift and E-region irregularities in, electrodynamic, 17: 32872
**IONS**
energy levels of one-electron, in high-temperature plasma, 17: 33191
heating of, resonance ion-cyclotron, 17: 33154(R) (ORNL-3472(p.50-5))
interactions with electric dipoles, angular collective variables for energy of, 17: 32795
interactions with electron beams in warm plasma, magnetic field effects on energy gain in, 17: 33194
reactions with nuclei, multiple Coulomb excitation from, 17: 33087
temperatures in PIG reflex discharges, measurements of, 17: 33168
**IRIDIUM**
properties of, for use in thermocouples, mechanical and thermoelectric, 17: 32644
**IRIDIUM ISOTOPES Ir-194**
use as tracer in pulp and paper research, 17: 32328
**IRON**
abundance in 3 Centauri A, 17: 32851
alloying effects on corrosion and mechanical properties of zirconium, 17: 32484(R) (GEAP-4284)
content in tissues, effects on radiation pathology, 17: 31928
determination in drill core samples of iron ores by x-ray fluorescence, 17: 32016
determination of $10^{-9}$ samples of, activation method for, 17: 32026
effects of, on shielding properties of lead, 17: 33256
effects on reduction of niobium alloys, 17: 32492
gamma scattering from point source in, 17: 32923
grain size in, effects of zirconium and its carbides, nitrides, and oxides on austenitic, 17: 32627
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
radiation effects on microstructure of alpha-, ionic, 17: 32673
radiation effects on, neutron, 17: 31798(R) (BNL-782(p.60-91))
separation from acid-ether solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from bismuth by ion exchange, 17: 32195(T) (KFK-tr-130)
separation from titanium by cation exchange chromatography, 17: 32054
solvent properties of, for hydrogen, effects of cerium, lanthanum, neodymium, and praseodymium on, 17: 32597
**IRON ALLOYS**
radiation effects on microstructure of alpha-, ionic, 17: 32673
radiation effects on, neutron, 17: 31798(R) (BNL-782(p.60-91))
Al–Fe–Zr, oxidation and mechanical properties, 17: 32621
Cr–Cu–Fe–Ni, radiation effects on magnetic properties of, 17: 32692
Cu–Fe, production of, by sintering at 470 to 1150°C, 17: 32497
Fe–Mo–Ni, radiation effects on magnetic properties of, 17: 32692
Fe–Mo–Ti, magnetic properties of, 17: 32651
Fe–Mo–Zr, oxidation and mechanical properties, 17: 32621
Fe–Ni, radiation effects on magnetic properties of, 17: 32692
Fe–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
Fe–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519
**IRON CARBIDES**
structural analysis of, using thermal neutrons, 17: 32057
**IRON COATINGS**
deposition and stability of, on beryllium, 17: 32574 (PWA-2184)

**IRON COMPLEXES**
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068
**IRON COMPOUNDS**
with rare earths of form $AFe_3$, magnetic properties and nuclear hyperfine fields of, 17: 32819
**IRON(II) IONS**
determination in oxalate solutions by cerium(IV) sulfate, 17: 32024
**IRON(III) IONS**
yield of, in radiolysis of ferrous sulfate, effects of oxygen concentration in 0.8 *N* sulfuric acid on, 17: 32162
yield of, in radiolysis of ferrous sulfate, effects of oxygen concentration in 0.05 *N* sulfuric acid on, 17: 32163
**IRON ISOTOPES Fe-54**
neutron reactions (n,p) on, neutron dosimetry by, 17: 32295(T) (CEA-tr-A-1221)
**IRON ISOTOPES Fe-55**
energy levels of, spins and transition correlations of, 17: 32725(R) (PR-P-57(p.37-43))
**IRON ISOTOPES Fe-56**
neutron inelastic scattering on, optical model for cross sections of, 17: 33048
**IRON ISOTOPES Fe-57**
energy levels of, spins and transition correlations of, 17: 32725(R) (PR-P-57(p.37-43))
energy levels of, spin of, 17: 33090
**IRON ORES**
analysis of drill core samples of, for calcium and iron by x-ray fluorescence, 17: 32016
**IRON OXIDES**
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
sorptive properties for cesium, tracer studies of, 17: 32044(R) (TID-19183)
**IRON(III) OXIDES**
additive effects on hardness of zirconia at room temperature, 17: 32484(R) (GEAP-4284)
separation of zirconium oxide from, as function of $SO_3$–$ZrO_2$ ratio, 17: 32077
**IRON SILICATES**
sorptive properties for cesium and strontium, 17: 32046(R) (TID-19185)
**IRON(II) SULFATES**
radiolysis of, effects of oxygen concentration in 0.8 *N* sulfuric acid on iron(III) yield in, 17: 32162
radiolysis of, effects of oxygen concentration in 0.5 *N* sulfuric acid on iron(III) yield in, 17: 32163
sensitivity increase in dosimeter solutions of, 17: 32460
**IRON SULFIDE CRYSTALS**
sulfur-35 exchange between hydrogen sulfide and, 17: 32138
**IRON SYSTEMS**
Fe–Nb–Si, effects of carbon content on properties and reduction of, 17: 32492
Fe–UC, phase studies, 17: 32637
Fe–$UC_2$, phase studies, 17: 32637
Fe–UN, phase studies, 17: 32637
**IRRADIATION FACILITIES**
design for measuring creep rate in fast neutron field, 17: 32697
design of, for ISPRA-I reactor, 17: 33365 (EUR-374.e)
design of low-level with cobalt-60 source for classroom use, engineering for, 17: 32383
**IRRADIATION TECHNIQUES**
for polymers during extruding or rolling, 17: 32700(P)
**ISOLEUCINE**
mutations in Saccharomyces for locus of, suppressor, 17: 31821
**ISOPROPYL ETHER**
solvent properties for uranium, 17: 32194(R) (TID-19068)
**ISOTOPE SEPARATION METHODS**
by continuous or stagewise process, mathematical model for, 17: 32468 (TID-18966)
distillation and exchange, mass transfer in, 17: 32470
for deuterium enrichment by isotope exchange between hydrogen and water in hot-cold columns, 17: 32473(P)
gaseous thermal diffusion, design criteria for equipment for, 17: 32467 (CONF-8-5)
theory of ideal cascades, 17: 32472
**ISOTOPES**
abundance determination in molecules from emission spectra, 17: 32022
separation of stable, definition of terminology in, 17: 32471
**ISOXAZOLE**
vibrational frequencies of deuterated and undeuterated, 17: 32145

## J

**JAPAN**
fallout monitoring, 1957 to 1962, 17: 32300
fallout particles in Osaka microanalytical studies of, 17: 32302
**JOINTS**
design for tubular members, 17: 32228(P)
**JOURNAL BEARINGS**
performance of mercury-lubricated, analysis of, 17: 32249(R) (SY-646-2)

## K

**KATANGA REGION (BELGIAN CONGO)**
uranium minerals in, age of, 17: 32265
**KENTUCKY**
radiological health program in, one year's experience, 17: 32316
**KEROSENE**
kerosene–tributylphosphate, analysis for uranium, 17: 32000
**KIDNEYS**
lysozyme activity in, of mouse radiation chimeras, 17: 31919
mercury poisoning of, effects on life span of mice, 17: 31827
radiation effects on dogs, protective effects of unithiol against, 17: 31968
**KILNS**
design of spray calciner, 17: 33411(P)
**KRYPTON**
ionization by protons, cross sections for, 17: 32790
proton scattering by, two-electron exchange cross sections in, 17: 33077
sorption by graphite, surface area measurement by, 17: 31795(R) (BNL-782(p.18-43))
**KRYPTON ISOTOPES $Kr^{85}$**
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
range in tungsten trioxide at 40 kev, 17: 32747
release from uranium dioxide crystals, 17: 33320(R) (ORNL-3445(p.63-108))
**KRYPTON ISOTOPES $Kr^{87}$**
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
release from uranium dioxide crystals, 17: 33320(R) (ORNL-3445(p.63-108))
**KRYPTON ISOTOPES $Kr^{88}$**
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
release from uranium dioxide crystals, 17: 33320(R) (ORNL-3445(p.63-108))
**KRYPTON ISOTOPES $Kr^{89}$**
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273

## L

**LABORATORIES**
description of NASA, for studies of space radiation effects, 17: 32699
design for plutonium fuel development, 17: 32537 (HW-SA-2904)
design of radioisotope, 17: 31805
**LABORATORY EQUIPMENT**
radioisotope storage area, 17: 32296

**LANTHANUM**
alloying effects on mechanical properties of magnesium–manganese–thorium alloys, 17: 32595
effects on solubility of hydrogen in iron, 17: 32597
effects on surface tension of Armco steels, 17: 32598
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
separation from titanium by cation exchange chromatography, 17: 32054
spectra of, infrared, 17: 32739
**LANTHANUM BORATES**
crystal structure and composition, 17: 32035 (CONF-20-28)
structural polymorphism of rare earth borates with, 17: 32124
**LANTHANUM BORIDES**
nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083
**LANTHANUM CHELATES**
with Thoron, properties and stability of, 17: 31983
**LANTHANUM CHLORIDES**
electric field parameters from orbital electrons of lanthanum trivalent ions in crystalline, 17: 32090
vapor pressure, 17: 32118
**LANTHANUM CHROMATES**
preparation and properties, 17: 32102
**LANTHANUM IONS**
electric field parameters from orbital electrons of trivalent, in trichloride crystals, 17: 32090
**LANTHANUM ISOTOPES La-127**
half life of, produced by antimony-119 (carbon-12, 4n) reaction, 17: 33023
**LANTHANUM ISOTOPES La-128**
half life of, produced by antimony-120 (carbon-12, 4n) reaction, 17: 33023
**LANTHANUM ISOTOPES La-129**
half life of, produced by antimony-121 (carbon-12, 4n) reaction, 17: 33023
half life of, produced by barium-130 (p,2n) reaction, 17: 33023
**LANTHANUM ISOTOPES La-130**
half life of, produced by barium-130 (p,n) reactions, 17: 33023
**LANTHANUM ISOTOPES La-131**
half life of, produced by antimony-123 (carbon-12, 4n) reaction of, 17: 33023
**LANTHANUM ISOTOPES La-139**
boron-10 reactions ($B^{m}$,7n) at 84.4–103.7 Mev, samarium-142 recoil range in, 17: 33094
**LANTHANUM ISOTOPES La-140**
use as tracer in pulp and paper research, 17: 32328
**LANTHANUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**LANTHANUM OXIDES**
$BaO–Cs_2O–La_2O_3–Li_2O–SiO_2$, electrochemical properties of, effects of added oxides on, 17: 32098
$BaO–La_2O_3–Li_2O–SiO_2$, electrochemical properties of glass, 17: 32097
$Cs_2O–La_2O_3–Li_2O–SiO_2$, electrode properties of glass, 17: 32096
**LANTHANUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**LANTHANUM SULFATES**
thermal decomposition and structure of enneahydrate, 17: 32062
**LANTHANUM SULFIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**LANTHANUM TELLURIDES**
crystal structure, 17: 32125
preparation and crystalline parameters, 17: 32121
**LAUNDRIES**
protection during handling of beryllium-contaminated protective clothing, 17: 32291 (UCRL-7311)
protective clothing monitoring system for, 17: 32286 (HW-76351)
**LEAD**
content in Atlantic Ocean, Mediterranean Sea, and snow, 17: 32274
dissolution in lead chloride, spectrophotometric study of, 17: 31795(R) (BNL-782(p.18-43))
electron slowing-down spectra in, 17: 32826
gamma reactions (γ,n), photoneutron yield, 17: 33032
gamma scattering from point source in, 17: 32923
nuclear shapes and sizes in, 17: 33073
properties of, as shielding material, effects of impurities on, 17: 33256
separation from bismuth by ion exchange, 17: 32195(T) (KFK-tr-130)
**LEAD CHLORIDES**
solvent properties for lead, spectrophotometric study of, 17: 31795(R) (BNL-782(p.18-43))
**LEAD ISOTOPES**
composition in snow, 17: 32274
**LEAD ISOTOPES Pb-199**
production in lithium-6 reactions with gold-197 at 15–40 Mev, excitation functions for, 17: 33038
**LEAD ISOTOPES Pb-200**
production in lithium-6 reactions with gold-197 at 15–40 Mev, excitation functions for, 17: 33038
**LEAD ISOTOPES Pb-203**
beta spectra measurements by solid-state detectors, 17: 32421
conversion electron-gamma coincidence spectra, 17: 32421
**LEAD ISOTOPES Pb-214**
content in atmosphere, 17: 32280
**LEAD SULFIDE CRYSTALS**
sulfur-35 exchange between hydrogen sulfide and, 17: 32138
**LEAK DETECTORS**
design of radiometric, for monitoring radon leaks, engineering drawings for, 17: 32376
**LEUKEMIA**
treatment of, in chickens using phosphorus-23, 17: 31825
**LEUKOCYTES**
radiation effects on, therapeutic, 17: 31906
radiation effects on intensity of second fluorescence of, in mice, 17: 31952
**LEUKOPENIA**
development from gamma therapy, characteristics of, 17: 31904
**LEVEL INDICATORS**
description of capacitance-type, for liquid helium, 17: 32365
**LEVEL REGULATORS**
design of radiometric, engineering drawings for, 17: 32373
**LIFE SPANS**
effects of mercury poisoning of kidneys on, in mice, 17: 31827
radiation effects, in dogs, 17: 31868(R) (UCD-107(p.275-81))
**LIGHT SOURCES**
properties of nanosecond hydrogen flash tubes, 17: 32212
**LIGNIN**
radiation effects on, 17: 32329
**LIGURIAN SEA**
plankton beta activity in, May 1961 to Nov. 1962, 17: 31845
**LIMONITES**
sorptive properties for cesium, tracer studies of, 17: 32044(R) (TID-19183)
**LINEAR ACCELERATORS**
book: *Theory and Calculations of Linear Accelerators*, 17: 33138
design and performance of 200-amp electron, 17: 33119 (UCRL-7408)
design of 300-Mev proton, 17: 33113 (CONF-125-3)
development of electron, worldwide, 17: 32917 (TID-7668(Sect.IX))
electron, use with neutron spectrometer for pulsed photoneutron studies, 17: 33032
instrumentation systems for, development of transistorized, 17: 32347
parameter optimization for given uses, 17: 33135
proton sources for, description of polarized, 17: 33130
**LIPIDS**
radioinduced free radicals in, in rat liver and spleen, 17: 31927
**LIQUID FLOW**
bubble motion in, 17: 32250 (TID-19224)
stability of rotatory superfluid, 17: 32808
**LIQUIDS**
activity coefficients of dilute binary solutions of metals, 17: 32633
density of, radiometric measurements of, 17: 32321
**LITHIUM**
alpha reactions (α,n) with, neutron yields from, 17: 33017

atomic wave functions for, with five parameters, 17: 32796
determination by alpha activation, 17: 32015
electric conductivity of, effects of pressure on, 17: 32753
electronic structure, 17: 32659
hyperfine splitting in ground-state, wave functions for, 17: 33102
performance of pure vapors of, in magnetohydrodynamic cells, 17: 32817
separation from basic solutions by ion exchange, 17: 32205(P)

**LITHIUM ALLOYS**
Al–Li, radioinduced tritium production in, 17: 33110(P)
Al–Li, recrystallization of helium-containing cold-worked and irradiated, 17: 32603

**LITHIUM ALUMINATES**
phase transitions in $LiAl_5O_8$, 17: 32599

**LITHIUM BROMIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084

**LITHIUM CHLORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084

**LITHIUM CHLORIDES**
$BaCl_2$–LiCl–NaCl, phase studies, 17: 32120
LiCl–KBr, phase studies, 17: 32113
LiCl–TlBr, phase studies, 17: 32113

**LITHIUM FLUORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084

**LITHIUM FLUORIDES**
preparation of magnesium-free, from lithium hydroxide, 17: 32193 (ORNL-TM-637)
radiation effects on thermoluminescent properties of, 17: 32402(R) (TID-19112)

**LITHIUM GLASS**
electrochemical properties of rare earth-containing, 17: 32094
electrochemical properties of, effects of zirconia on, 17: 32095
electrochemical properties of, effects of added oxides on, 17: 32098
use of cerium-activated, for neutron detection, 17: 32405 (ZFK-RN-19)

**LITHIUM HYDROXIDES**
separation from magnesium by solvent extraction, 17: 32193 (ORNL-TM-637)

**LITHIUM IODIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084

**LITHIUM ISOTOPES Li-6**
alpha reactions (α,d) at 23.7 and 24.5 Mev, angular distributions from, 17: 33014
lithium-6 reactions ($Li^6$,α), angular distributions from, 17: 33088
reactions ($Li^6$,α) with carbon-12 and lithium-6, angular distributions from, 17: 33088
reactions ($Li^6$,5n) with praseodymium-141 at 50.6–62.5 Mev, samarium-142 recoil range from, 17: 33094
reactions with beryllium-9, alpha-gamma coincidence spectra, 17: 32423
reactions with gold-197 at 15–40 Mev, excitation functions for nuclei $196 \leq A \leq 200$ production in, 17: 33038

**LITHIUM ISOTOPES Li-7**
reactions ($Li^7$,6n) with praseodymium-141 at 64.6–71.8 Mev, samarium-142 recoil range from, 17: 33094

**LITHIUM ISOTOPES Li-8**
production in proton fission of bromine and silver, 17: 33081

**LITHIUM NITRATES**
electrode processes in, 17: 31797(R) (BNL-782(p.51-9))

**LITHIUM OXIDES**
molecular structure and polarity of, electric deflection studies of, 17: 32030 (AROD-006.9)
BaO–$Cs_2O$–$La_2O_3$–$Li_2O$–$SiO_2$, electrochemical properties of, effects of added oxides on, 17: 32098
BaO–$La_2O_3$–$Li_2O$–$SiO_2$, electrochemical properties of glass, 17: 32097
$Cs_2O$–$La_2O_3$–$Li_2O$–$SiO_2$, electrode properties of glass, 17: 32096

**LITHIUM SULFATES**
cerium polarography in, 17: 32099

**LITTER SIZES**
radiation effects, in dogs, 17: 31865(R) (UCD-107(p.98-111))

**LIVER**
radiation effects on cytochromoxidase and succinic dehydrogenase activity in rabbit, fractionated gamma and x-ray, 17: 31979
radioinduced mutations in mouse, comparison of gamma and neutron, 17: 31958

**LOS ALAMOS TURRET REACTOR**
development of, Mar. 20–June 20, 1963, 17: 33314(R) (LAMS-2933)

**LUBRICANTS**
radiation effects on, cosmic, 17: 32693

**LUBRICATION**
of rails in winter, tracer study of, 17: 32326
theory of laminar and turbulent, 17: 32249(R) (SY-5455-R)

**LUMINESCENT MATERIALS**
radiation dosage from dials and television sets coated with, 17: 32309

**LUNGS**
histaminase activity, effects of adrenal gland irradiation and pertussis sensitization, 17: 31910
radiation effects on, review of, 17: 31965
strontium-90 absorption from, 17: 31835

**LUTETIUM**
spectra of, infrared, 17: 32739
spectra of neutral, Zeeman effect analysis of, 17: 32750

**LUTETIUM BORATES**
$LaBO_3$–$LuBO_3$, structural polymorphism of, 17: 32124

**LUTETIUM CHLORIDES**
vapor pressure, 17: 32118

**LUTETIUM IONS**
spectra of, Zeeman effect data for, 17: 32751

**LUTETIUM ISOTOPES Lu-175**
internal conversion line intensity ratio for, anomalous L, 17: 32724(R) (PR-P-57(p.21-36))

**LUTETIUM ISOTOPES Lu-177**
internal conversion line intensity ratio for, anomalous L, 17: 32724(R) (PR-P-57(p.21-36))

**LUTETIUM NITRIDES**
properties of, electric and magnetic, 17: 32081

**LUTETIUM SULFIDES**
properties of, electric and magnetic, 17: 32081

**LUTIDINES**
effects of tritiated water on, in presence of ammonium chloride, 17: 32142

**LYMPH CELLS**
circulation, tracer study, 17: 31917
formation, circulation, and life span, tracer studies, 17: 31852 (BNL-7137)
preparation of labeled, 17: 31917
radiosensitivity, 17: 31852 (BNL-7137)

**LYMPH SYSTEM**
physiology, tracer studies, 17: 31852 (BNL-7137)
radiation effects on reaction to injected dyes, whole-body exposure, 17: 31924
radiation effects on protein metabolism in, tracer study of, 17: 31932

**LYSOZYME**
activity, in kidneys of mouse radiation chimeras, 17: 31919


# M


**MAGNESIUM**
alpha reactions (α,n) with, neutron yields from, 17: 33017
alpha reactions (α,n) with, neutron yields from, 17: 33018
determination in gallium arsenide, activation, 17: 32004
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
dissolution in magnesium chloride, chronopotentiometric study of, 17: 31795(R) (BNL-782(p.18-43))
electronic structure, 17: 32659
grain boundary cavitation in, effects of moist carbon dioxide on, 17: 32584
separation from bismuth by ion exchange, 17: 32195(T) (KFK-tr-130)
separation from lithium hydroxide by solvent extraction, 17: 32193 (ORNL-TM-637)
separation from titanium by cation exchange chromatography, 17: 32154
spectra of, infrared, 17: 32739

**MAGNESIUM ALLOYS**
Al–Mg–Zn, effects of polarization on stress corrosion of, 17: 32538
Be–Mg, fabrication of super heat-resistant, 17: 32553
Ce–Mg, hydrogen absorption, 17: 32643

Mg–Mn–Th, effects of alloying agents on mechanical properties of, 17: 32595
Mg–Nd, decomposition of supersaturated neodymium-rich solid solution in, 17: 32594
Mg–Th, properties and structure of, alloying effects of manganese and zirconium on, 17: 32596
**MAGNESIUM ALUMINATES**
point defect sites in crystals of, internal friction peak from symmetry splitting of equivalent, 17: 32607
**MAGNESIUM CHLORIDES**
solvent properties for magnesium, chronopotentiometric study of, 17: 31795(R) (BNL-782(p.18-43))
**MAGNESIUM ISOTOPES Mg-24**
alpha elastic and inelastic scattering at 22.5 Mev, differential cross sections for, 17: 33101
alpha inelastic scattering at 22.5 Mev, magnetic substates population from, 17: 33099
energy levels, 17: 32723(R) (PR-P-57(p.5-20))
energy levels of, spin assignments for, 17: 33012
gamma spectra, 17: 32435
**MAGNESIUM ISOTOPES Mg-26**
energy levels of, spin assignments for, 17: 33012
triton reactions (t,p) at 2.7 Mev, cross section for, 17: 31797(R) (BNL-782(p.51-9))
**MAGNESIUM ISOTOPES Mg-28**
production of high specific activity, 17: 31797(R) (BNL-782(p.51-9))
**MAGNESIUM OXIDE CRYSTALS**
point defect sites in, internal friction peak from symmetry splitting of equivalent, 17: 32607
**MAGNESIUM OXIDES**
additive effects on creep, hardening, and strength of uranium alloys, 17: 32657
deformation and grain boundaries in, 17: 32584
electric conductivity of, for use as insulation in thermocouples, 17: 32644
separation of zirconium oxide from, as function of $SO_3$–$ZrO_2$ ratio, 17: 32077
thermodynamic properties at 298 to 1200°K, 17: 32086
CaO–MgO–$ZrO_2$, phase studies, 17: 32653
Mg–MgO, fabrication of super heat-resistant, 17: 32553
MgO–$UO_2$, fabrication, properties, and radiation stability of, 17: 33262
MgO–$ZrO_2$, phase studies, 17: 32653
**MAGNESIUM SYSTEMS**
Mg–MgO, fabrication of super heat-resistant, 17: 32553
**MAGNET COILS**
thermal switches for coolant system for, response of, 17: 33158(R) (ORNL-3472(p.84-106))
**MAGNETIC FIELDS**
annihilation and reconnection of, in solar flares, 17: 32859
charged particle motion in dipole, 17: 32878
distribution around cylindrical conductors, helically symmetric, 17: 32797
effects of strength of, on magnetization of gadolinium at 298°K, 17: 32646
effects on electroconductivity of gases, 17: 32814
effects on energy gain in electron beam-plasma ion interactions, 17: 33194
effects on rotating fluids, 17: 32874
electromagnetic wave propagation through plasma slabs in, 17: 33218
measurement for planets and satellites, 17: 32879
plasma stability in uniform, h-f electrostatic, 17: 33195
pole surfaces for strong- and weak-focusing, 17: 32791
production in solar photosphere, kinetic theory of, 17: 32854
sphere motion through conducting fluid in transverse, non-conducting, 17: 32783
sphere motion through conducting fluid in transverse, conducting and non-conducting, 17: 32784
**MAGNETIC MATERIALS**
neutron scattering by, thermal, 17: 32987
**MAGNETIC MIRROR MACHINES**
developments at ORNL, 17: 33151(R) (ORNL-3472(p.1-8))
end closures for, solenoid arrangement for, 17: 33221(P)
hydrogen atom and molecular ion accumulation and injection in, high-energy, 17: 33187
injection into, possibilities of very high-energy, 17: 33160(R) (ORNL-3472(p.119-20))
particle motions in, equations for, 17: 33165
plasma magnetic field measurements in Scylla I theta pinch, 17: 33178
plasma properties and stabilization in, 17: 33152(R) (ORNL-3472 (p.9-23))
**MAGNETIC RECORDING SYSTEMS**
development and operation of multiparameter pulse-height, 17: 32343 (UCRL-10874)
use of two-channel tape, for data from scintillation scanning of radio-isotopes in body organs, 17: 32351
**MAGNETIC RESONANCE**
spin induction in electron, 17: 32754
**MAGNETO-OPTICAL ROTATION**
measurement in plasma, microwave-cavity, 17: 33198
**MAGNETOHYDRODYNAMIC CELLS**
development at Brookhaven, 17: 31794(R) (BNL-782(p.1-17))
entropy production and performance of, for space systems, 17: 32824
performance for space uses, using superconducting magnets, 17: 32224
performance of Mark II, fluid mechanical studies of, 17: 33212
performance of, using non-equilibrium ionization in alkali metal vapors and seeded gas systems, 17: 32817
**MAGNETOHYDRODYNAMICS**
conducting flow in rectangular channel in transverse fields, 17: 32813
energy conversion in inhomogeneous flow, 17: 33219
equations for one-dimensional unstable flow in strong fields, 17: 32755
flow of conducting incompressible fluid over plate in magnetic field, 17: 32781
fluid flow discontinuity in, stability of Kelvin-Helmholtz, 17: 32774
fluid flow in, angle indicator for, 17: 32388
fluid rotation in, magnetic field effects on behavior of, 17: 32874
instability of compressed fluid in, 17: 32812
kinetic theory of hydromagnetic fields, 17: 32854
oscillations of conducting fluid in magnetic field, 17: 32782
oscillations of viscous liquid sphere in rotation, equations of torsional, 17: 33184
plasma flow in insulated channels, boundary layer effects on, 17: 33201
plasma instabilities in, effects on solar flare production, 17: 33166
plasma properties, calculation of nonequilibrium monatomic, 17: 33208
plasma stability in, resistivity effects on multipolar, 17: 33175
plasma stability in strong magnetic fields, 17: 33188
shock strength vs. area variations in channels, 17: 32742
skin effect in traveling-wave devices, 17: 32775
source current motion along magnetic fields, 17: 32708 (D1-82-0254)
**MAGNETOMETERS**
description of, for geomagnetic field mapping, 17: 32862
design for weak fields using Overhauser effect, 17: 32745
development of low-temperature micro-, 17: 33158(R) (ORNL-3472 (p.84-106))
**MAGNETS**
design for FFAG accelerators, 17: 33115 (CONF-125-S)
design of weight-optimized superconducting, 17: 32224
development and performance of superconducting aluminum, 17: 33149(R) (NBS-7919)
optical properties of quadrupole doublets, 17: 32703 (BNL-795)
pole surfaces for strong- and weak-focusing, 17: 32791
properties of superconducting, 17: 32712 (LNF-63/26)
**MAGNOX ALLOYS**
creep cavitation in A12, 17: 32613
**MAIZE**
radiation effects on seeds of, from satellite flights, 17: 31947
**MALEIC ACID, DIETHYL ESTER**
radioinduced polymerization with styrene, 17: 32177
**MALEIC ANHYDRIDE**
radioinduced polymerization of unsaturated esters of, with styrene, 17: 32177
**MALEIMIDE, *N*-PHENYL-**
effects on radioinduced vulcanization of saturated polymers and synthetic rubbers, 17: 32167
**MALEIMIDE, *N,N'*-PHENYLENEDI-**

effects on radioinduced vulcanization of saturated polymers and synthetic rubbers, 17: 32167

**MAN**

analysis for phosphorus-32 distribution, radiometric, 17: 31876
iodine-131 content in, in Utah from 1962 fallout, 17: 31848
oxygen balance in, effects of cystamine and S-beta-amino ethylisothiuronium on, 17: 31833
radiation sickness in, case history of ophthalmological changes in acute, 17: 31978
regulations for radiation protection of, in x-ray testing of steel tube welding seams, 17: 32307
strontium-90 uptake from foods by, 1961, 17: 31846

**MANGANESE**

abundance in 3 Centauri A, 17: 32851
alloying effects on properties and structure of magnesium–thorium alloys, 17: 32596
determination in natural diamonds, activation, 17: 31995
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
separation from cobalt by ion exchange, 17: 31797(R) (BNL-782(p.51-9))
separation from titanium by cation exchange chromatography, 17: 32054
spectra of, infrared, 17: 32739

**MANGANESE ALLOYS**

Al–Cu–Mn, paramagnetism and valency in, 17: 32561 (AE-111)
Cu–Ge–Mn, paramagnetism and valency in, 17: 32561 (AE-111)
Cu–Mn–Zn, paramagnetism and valency in, 17: 32561 (AE-111)
Mg–Mn–Th, effects of alloying agents on mechanical properties of, 17: 32595
Mn–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
Sb–Cr–Mn, magnetic structures in, 17: 32622

**MANGANESE FERRATES**

preparation of crystals of, by zone melting at 2320 to 3800°K, 17: 32590

**MANGANESE ISOTOPES Mn-54**

content from fallout in mollusks, relation of, to age, 17: 31847

**MANGANESE ISOTOPES Mn-56**

production in Szilard-Chalmers reactions with potassium nitrosylopentacyanomanganate, 17: 32168

**MANGANESE OXIDES**

free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)

**MANGANESE STEEL**

Mn–Si, radiation effects on plastic deformation of, 17: 32684

**MANOMETERS**

design of electro-pneumatic constant-volume, 17: 32337 (K-1577)

**MARITIME REACTORS**

core and fuel element design for, 17: 32236(P)
design and development of 630A, summary of, 17: 33312(R) (GEMP-215)
design of Danish Alpha II and American Consolidated Nuclear Steam Generator, 17: 33335
moderator flow-control device for, 17: 33293(P)

**MASERS (OPTICAL)**

properties of 3- and 4-level, 17: 32804

**MASS SPECTROGRAPHY**

analysis of solids by, ion source for, 17: 32389

**MASS SPECTROMETERS**

charged-particle detector for magnetic analyzers, 17: 32428
design for chemical reaction observations, 17: 32360
development and uses of, review of, 17: 32350
ion source pressure measurement at very high pressures in, 17: 32387
matrix treatment of ion focusing in Browne-Buechner, 17: 32362
operation at low pressures, mass peaks from adsorbed gases in, 17: 32345
sampling by, through pinhole in the adiabatic flow region, 17: 32361

**MATERIALS TESTING**

measurement of grain size in outer annular region of metal bars by ultrasonics, 17: 32263(P)
nondestructive, design and operation of 31-Mev betatron for, 17: 32609
nondestructive, design and characteristics of 18-Mev betatron for, 17: 32610
ultrasonic methods for fatigue testing, 17: 32262 (HW-SA-2927)

**MATERIALS TESTING REACTOR MOCKUP**

control rod calibration for, by rod-drop method, 17: 33374 (ORNL-TM-605)

**MATHEMATICS**

analog to digital conversion, errors and precisions in, 17: 32408
analysis of linear systems by calculation of the time domain, computer program for, 17: 32476 (UCRL-10927)
calculation of ground-state properties of many-particle systems using reduced density matrices, 17: 33227 (NYO-10431)
eigenvalues of a matrix, methods for computing, 17: 33226 (NYO-10429)
matrix diagonalization in, numerical computations for random, 17: 32481
operator representation of Lie algebra in, three-dimensional homogeneous rotation group for, 17: 32478
theorems for unitary operator construction, 17: 32717(R) (NP-12996(p.25-35))

**MATTER**

charged-particle multiple scattering in, 17: 32931
kinetic theory of, stationary-state, 17: 32766

**MECHANICAL ENGINEERING**

tracer study of cylinder and piston ring wear, 17: 32226

**MECHANICS**

extension of APT computer system to obtain centroids and inertias of surfaces and solids, 17: 32477 (Y-1420)
operator representation of Lie algebra in classical, three-dimensional homogeneous rotation group for, 17: 32478
theory of continuous representation in classical, generalized relation to quantum dynamics, 17: 32763

**MEDICINE**

radiosterilization of glass ampules containing, 17: 32675
use of gold-198 in, bibliography on, 17: 31814 (KFK-143)
use of radioisotopes in surgery, 17: 31828

**MEMORY DEVICES**

model for associative memory, mathematical, 17: 32475 (SCR-641)

**MERCURY**

corrosive effect, 17: 31798(R) (BNL-782(p.60-91))
effects of kidney poisoning by, on life span of mice, 17: 31827
heat transfer to, from rods, 17: 31795(R) (BNL-782(p.18-43))
performance of cesium seeded plasma of, in magnetohydrodynamic cells, 17: 32817
solvent properties, 17: 31798(R) (BNL-782(p.60-91))

**MERCURY ALLOYS**

Hg–Tl, electrode processes on, in perchlorate solution, 17: 32642
In–Hg, electrode processes on, in perchlorate solution, 17: 32642

**MERCURY IONS**

production for propulsion systems, development of controlled-growth colloidal source for, 17: 32217

**MERCURY ISOTOPES Hg-197**

production in lithium-6 reactions with gold-197 at 15–40 Mev, excitation functions for ground-state and isomeric, 17: 33038

**MERCURY ISOTOPES Hg-198**

gamma spectra of, absolute energy of 412-kev line in, 17: 33050

**MERCURY ISOTOPES Hg-203**

use as tracer in pulp and paper research, 17: 32328

**MESIC ATOMS**

formation of $\mu$-mesic helium, 17: 33080

**MESONS**

interactions of vector, effects on meson ($\pi$) interactions, 17: 32950
photoproduction of vector, theory, 17: 32913 (TID-7668(Sect.V))
photoproduction of, 17: 32916 (TID-7668(Sect.VIII))
theory of charged vector, Lee-Yang, 17: 32959

**MESONS ($\eta$)**

parity and spin of, 17: 32941
photoproduction on protons, cross section for, 17: 32912 (TID-7668(Sect. IV))

**MESONS (K)**

interactions with protons, fermion Regge poles for asymptotics of, 17: 32933
interactions with mesons (K) and ($\pi$), properties of elastic, 17: 32951
parity and spin of K, $\bar{K}$, K*, and $\bar{K}$*, 17: 32941
production in antinucleon annihilation and meson ($\pi$)-nucleon interactions, cross sections for, 17: 32920
production in meson (K )-proton interactions at 2.3 Bev/c, 17: 32898 (BNL-7105)

**MESONS ($K^-$)**

interactions with protons at 2.7 to 5.2 Bev/c, total cross section for,

17: 32897 (BNL-6962)
interactions with protons at 2.3 Bev/c, resonance production in ($\Xi$-K-$\pi$) final-state, 17: 32898 (BNL-7105)
**MESONS ($K^0$)**
mass difference $K_1^0$–$K_2^0$, determination of sign of, 17: 32954
**MESONS ($K^+$)**
photoproduction on protons, excitation curve for, 17: 32912 (TID-7668 (Sect.IV))
**MESONS ($\mu$)**
capture by helium, mesic atoms from, 17: 33080
decay of, relativistic three-particle emission in, 17: 32921
photoproduction of pairs of, at wide angles, 17: 32916 (TID-7668(Sect. VIII))
reactions in supernova processes, neutrino emission from, 17: 32880
**MESONS ($\mu^-$)**
capture by hydrogen, meson ($\mu$)-electron universality in, 17: 33002 (NEVIS-116)
**MESONS ($\omega$)**
parity and spin of, 17: 32941
**MESONS ($\phi$)**
parity and spin of, 17: 32941
**MESONS ($\pi$)**
dispersion relations for, Green's function from, 17: 32948
interactions in meson ($\pi$)-nucleon scattering, S-wave dispersion relation in, 17: 32949
interactions of, effects on photon Green's function, 17: 32955
interactions of, intermediate-vector-meson model for, 17: 32950
interactions with nucleons, partial wave amplitudes for, 17: 32899 (CONF-46-80)
interactions with nucleons at $\leq$ 3 Bev, strange particle production cross sections in, 17: 32920
interactions with nucleons at low energy, S-wave dispersion relation in, 17: 32949
interactions with mesons (K), properties of elastic, 17: 32951
interactions with photons, amplitude for, 17: 32962
parity and spin of, 17: 32941
production by 10-Bev high-intensity FFAG accelerator, 17: 33114 (CONF-125-4)
production in antinucleon annihilation, cross sections for, 17: 32920
production in electron-nucleus reactions, cross section for, 17: 32913 (TID-7668(Sect.V))
production of pairs of, in electron-positron interactions, 17: 32958
scattering in nuclear emulsions, multiple, 17: 32931
**MESONS ($\pi^-$)**
capture at rest in hydrogen, Panofsky ratio for, 17: 32947
decay of, vector form factor in, 17: 32934
interactions with nucleons at 6.8 and 8.0 Bev/c, hyperons ($\Xi^-$) production in, 17: 32945
interactions with protons at 2 Bev/c, angular distributions for, 17: 32906 (NP-12990)
interactions with protons, diffraction scattering curve for, 17: 32911 (TID-7668(Sect.III))
**MESONS ($\pi^0$)**
detection of, device for, 17: 32915 (TID-7668(Sect.VII))
photoproduction of, theory, 17: 32913 (TID-7668(Sect.V))
photoproduction of, nuclear size measurement by, 17: 33106
photoproduction on protons, 17: 32912 (TID-7668(Sect.IV))
photoproduction on nuclei, distributions from, 17: 33073
**MESONS ($\pi^+$)**
decay of, vector form factor in, 17: 32934
photoproduction from protons, 17: 32964
photoproduction of, theory, 17: 32913 (TID-7668(Sect.V))
photoproduction on protons, 17: 32912 (TID-7668(Sect.IV))
**MESONS ($\rho$)**
parity and spin of, 17: 32941
**METABOLISM**
data analysis, electronic processing, 17: 31815 (LADC-5627)
radiation effects on rat, effects of nutritional condition on, 17: 31838
radiation effects from injected plutonium-239 on, in bone, 17: 31926
tracer studies, data analysis by electronic processing, 17: 31815 (LADC-5627)
**METAL CRYSTALS**
preparation and testing, 17: 32575(R) (TID-19181)
**METAL-FOIL DETECTORS**
use of resonance, for neutron flux spectra measurements, 17: 32418
**METALLIC FILMS**
deposition of thin, vacuum system shutter arrangement for, 17: 33149(R) (NBS-7919)
**METALLOGRAPHY**
developments at Brookhaven, 17: 31798(R) (BNL-782(p.60-91))
etching by monoenergetic ion bombardment, 17: 32505
**METALLURGY**
bibliography on effects of weld-pool agitation on properties and characteristics of welds, 17: 32533 (AD-409795)
developments at Brookhaven, 17: 31798(R) (BNL-782(p.60-91))
**METALS**
activity coefficients of dilute binary solutions of liquid, 17: 32633
bibliography on composites, 17: 32482 (AD-408618)
brazing of graphite to, feasibility of, 17: 32547
corrosion and wear of, engineering drawings of system using tracer techniques for determining, 17: 32380
decontamination of, using ultrasonics, 17: 32304
heat transfer to liquid, 17: 31795(R) (BNL-782(p.18-43))
nuclear magnetic resonance, 17: 32569 (CONF-54-1)
oxidation of, use of xenon-125 in studies of anodic, 17: 32532
physical properties of oriented polycrystalline, 17: 32631
preparation of chemically reactive, review of, 17: 32504
promotion of radiation effects on polymers by heavy, 17: 32700(P)
radiation effects on magnetic and mechanical properties of, 17: 32683
radiation effects on bcc, 17: 31798(R) (BNL-782(p.60-91))
sputtering rates, 17: 32770
**METEORITES**
analysis for hafnium and zirconium, neutron activation, 17: 31986 (TID-19179)
**METEOROIDS**
effects of penetration rate on propulsion system weights, 17: 32210
**METHACRYLIC ACID, METHYL ESTER**
graft polymerization of, on cellulose acetate, ceric ion, preirradiation, and radiation methods for, 17: 31809
radiation effects on, cosmic, 17: 32693
**METHACRYLIC ACID, METHYL ESTER POLYMERS**
radioinduced film formation from, on glass and quartz, 17: 32695
radiolysis, 17: 32176
**METHANE**
heat of desorption, 17: 33159(R) (ORNL-3472(p.107-18))
**METHANE, DICHLORODIFLUORO-**
use in binary cycle for nuclear power production, economic analysis of, 17: 33351
**METHANOL**
solvent additive effects on radioinduced graft polymerization of cotton cellulose and rayon on polystyrene, 17: 31808
solvent effects on radioinduced graft polymerization of styrene to viscose rayon yarn, 17: 32676
solvent properties for elements, 17: 32194(R) (TID-19068)
**MICE**
genetic effects of x irradiation for 20 generations of male, 17: 31853 (LADC-5618)
incorporation of tritium labeled amino acids into cell nuclei of, 17: 31887
radiation chimeras, lysozyme activity of kidneys, 17: 31919
radiation effects of fast neutrons and x rays on gonads of, 17: 31891
radiation effects on bone marrow cells in, proton, 17: 31942
radiation effects on, protective effects of S-ethylisothiuronium against, 17: 31948
radiation effects on intensity of second fluorescence of lymphocytes in, 17: 31952
radiation effects on muscles in, protective effects of cysteamine against, 17: 31967
radiation effects on, protective effects of drugs against, 17: 31966
radiation protection of hematopoiesis by hormones in, 17: 31941
**MICROORGANISMS**
regeneration of irradiated monocellular, effects of energy metabolism on, 17: 31890
scavenging of sorbed material from mineral particles by, tracer study,

17: 31830 (TID-19127)
**MICROWAVE EQUIPMENT**
radiation hazards and protection during operation, 17: 31911
theory of plasma waveguide, nonlinear, 17: 33185
**MICROWAVES**
interactions in magneto-plasma, electron cyclotron resonance absorption of energy from gyro-, 17: 33215
**MILK**
iodine-131 contamination of, after stock release, 17: 32284 (DPSPU-63-30-26B)
iodine-131 content in, in Utah from 1962 fallout, 17: 31848
iodine-131 deposition from, in thyroid gland, 17: 31849
**MINERAL METABOLISM**
effects of beta particles from injected phosphorus-32 on, in rats, 17: 31925
**MINERALS**
ages of vein, from Rwanda-Urundi, 17: 32268
book: *Radiogenic Argon in Minerals and Rock*, 17: 32278
strontium–rubidium ages of, from rocks of Kasai basement in Congo, 17: 32269
**MIRRORS**
neutron reflection from magnetized cobalt, polarization from, 17: 32977
**MISSILES**
flight through blast wave, axi-symmetric base pressure analysis of, 17: 32730 (TID-19116)
**MITOSIS**
radiation effects on, 17: 31935
radioprotective effects of AET on, in mice, 17: 31942
radiosensitivity of *Tradescantia paludosa* microspores during, changes in, 17: 31937
**MOLDS**
ascospore color in Aspergillus, 17: 31893
**MOLECULES**
electron wave function calculations for diatomic, use of diatomic orbitals in, 17: 32721 (NYO-10423)
isotopic abundance determination from emission spectra of, 17: 32023
production of meson ($\mu$), in hydrogen, 17: 33003 (NEVIS-117)
**MOLLUSKS**
content of manganese-54 from fallout in, relation of, to age, 17: 31847
environmental factors affecting distribution in Bogue Sound area, North Carolina, 17: 31817(R) (TID-19122)
**MOLTEN SALT REACTOR EXPERIMENT**
design of, revisions of data sheets for, 17: 33375 (ORNL-TM-638)
stresses of cast metal in, 17: 32573 (ORNL-TM-607)
**MOLYBDENUM**
cesium ionization on, efficiency of, 17: 32825
coating by zirconium from vapor of iodides, 17: 32507
coating of, effects of, on compression and high-temperature damage and oxidation, 17: 32526
crystal structure, 17: 32565 (ASD-TR-61-181(Pt.III))
desorption from, at low pressure and temperature, 17: 33159(R) (ORNL-3472(p.107-18))
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
determination of $10^{-9}$ samples of, activation method for, 17: 32026
diffusion in molybdenum–zirconium alloys, self-, 17: 32593
mechanical properties, 17: 32565 (ASD-TR-61-181(Pt.III))
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)
separation of, from bauxite by direct electrolysis and precipitation, economics of, 17: 32065
**MOLYBDENUM ALLOYS**
Cr–Mo–Zr, oxidation and mechanical properties, 17: 32621
Fe–Mo–Ni, radiation effects on magnetic properties of, 17: 32692
Fe–Mo–Ti, magnetic properties of, 17: 32651
Fe–Mo–Zr, oxidation and mechanical properties, 17: 32621
Ho–Mo–Zr, magnetic properties of, 17: 32651
Mo–Nb–W–Zr, mechanical properties of warm-extruded and rolled, 17: 32567 (BMI-X-249)
Mo–Ni–Zr, oxidation and mechanical properties, 17: 32621
Mo–Re, properties as superconducting magnet, 17: 32712 (LNF-63/26)
Mo–U, $\gamma$–$\gamma'$ transformation mechanism in, 17: 32605
Mo–U, heat treatment, 17: 32619
Mo–U, phase transformation, 17: 32619
Mo–U, stress corrosion cracking, 17: 32518 (Y-1417)
Mo–Zr, self-diffusion of molybdenum in, 17: 32593
**MOLYBDENUM CARBIDES**
coating of, with graphite, development of production scale procedure for, 17: 33279
**MOLYBDENUM COUPLES**
Mo–U, diffusion coefficients and Kirkendall effect in, 17: 32578(T) (AEC-tr-5932)
**MOLYBDENUM ELECTRODES**
cesium film behavior on, 17: 32827
**MOLYBDENUM OXIDES**
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
**MOLYBDENUM STEEL**
Cr–Mo, physical properties of carbonized, effects of air, helium, and sodium at 1100°F on, 17: 32571(R) (MSAR-63-105)
**MOLYBDENUM SYSTEMS**
C–Mo–Th, phase studies on arc-melted, pressure-sintered, and vacuum-annealed, 17: 32616
C–Mo–U, phase studies on arc-melted, pressure-sintered, and vacuum-annealed, 17: 32616
**MONKEYS**
effects of thorium oxide on sensitivity to toxin, 17: 31918
radiation effects on chromosomal rearrangement in spermatogenesis in, 17: 31950
**MONTE CARLO METHOD**
calculation of efficiencies and photofractions of scintillation detectors, 17: 32416
use in random matrix diagonalization, 17: 32480
**MOON**
magnetic field of, parameters for, 17: 32879
**MÖSSBAUER EFFECT**
experimental studies of, using Compton-scattered radiation, 17: 33034
kinetics of induced, in infinite crystals, 17: 33084
properties of, for tin-119 in stannate lattices, 17: 32107
**MULTIPLICATION FACTOR**
book: *Introductory Nuclear Reactor Theory*, 17: 33266
reactivity effects due to variations in nuclear parameters in a thermal power reactor, 17: 33307 (EUR-281.e)
theory of delayed supercritical excursions to measure Doppler coefficient of fast reactors, 17: 33242 (KFK-153)
**MUSCLES**
radiation effects on mouse, protective effects of cysteamine against, 17: 31967
**MUTATIONS**
induction by nitrous acid and ultraviolet in Aspergillus, 17: 31893
radiation effects on rate of, in Drosophila sperm, 17: 31895
radiation effects on occurrence frequency of, 17: 31936
radiation response in *Drosophila melanogaster*, gamma, 17: 31894
radioinduced and chemically induced in the moth Ephestia, reaction mechanisms in, 17: 31856(R) (TID-19166)
radioinduced in plants, 17: 31816(R) (ORO-605)
suppressor, for the isoleucine locus in Saccharomyces, 17: 31821

# N

**NEODYMIUM**
alloying effects on mechanical properties of magnesium–manganese–thorium alloys, 17: 32595
determination in presence of other rare earths, spectrophotometric, 17: 32002
effects on solubility of hydrogen in iron, 17: 32597
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
separation from praseodymium by ion exchange, 17: 32202
**NEODYMIUM ALLOYS**
Mg–Nd, decomposition of supersaturated neodymium-rich solid solution in, 17: 32594
**NEODYMIUM BORATES**
$LaBO_3$–$NdBO_3$, structural polymorphism of, 17: 32124
$NdBO_3$–$SmBO_3$, structural polymorphism of, 17: 32124
**NEODYMIUM BORIDES**

nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083
**NEODYMIUM CHLORIDES**
vapor pressure, 17: 32118
**NEODYMIUM CHROMATES**
preparation and properties, 17: 32104
**NEODYMIUM COMPLEXES**
with di-butyl phosphates, solubility in di-butyl phosphoric acid with various diluents, 17: 32149
with dibutyl phosphate, solubility in dialkyl phosphoric acids in benzene at 25°, 17: 32148
with octyl phosphate, solubility in dialkyl phosphoric acids in benzene at 25°, 17: 32148
**NEODYMIUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**NEODYMIUM OXIDES**
reactions with melted fluorides, 17: 32111
**NEODYMIUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**NEODYMIUM SULFIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**NEODYMIUM TELLURIDES**
crystal structure, 17: 32125
**NEON**
atomic wave functions for, with five parameters, 17: 32796
crystal structure of, isotopic effects on unit-cell volumes, 17: 32106
electric conductivity of cesium-seeded plasma of, near thermal equilibrium, 17: 33216
electric discharge in, positive column instability in, 17: 33161 (UCRL-10698)
helium ion interactions at 0.133 to 1 Mev, free electron and ion production in, 17: 32731 (TID-19137)
ionization by protons, cross sections for, 17: 32790
**NEON ISOTOPES Ne-20**
energy levels, 17: 32723(R) (PR-P-57(p.5-20))
energy levels of, spin assignments for, 17: 33012
nuclear spin of excited level of, 17: 33125
**NEON ISOTOPES Ne-21**
energy levels of, lifetimes of low-lying, 17: 33098
**NEON ISOTOPES Ne-22**
energy levels of, spin assignments for, 17: 33012
**NEPTUNIUM ISOTOPES**
neutron fission of, average number of fission neutrons in, 17: 33016
**NEPTUNIUM ISOTOPES Np-237**
neutron cross sections of, effective, 17: 33325(R) (ORNL-3445(p.251-97))
**NEPTUNIUM OXIDES**
preparation from molten salts, 17: 32073
**NERVOUS SYSTEM**
radiation effects, whole-body critical exposure, 17: 31816(R) (ORO-605)
radiation effects on reactions of, 17: 31908
radiation effects on cytochromoxidase and succinic dehydrogenase activity in rabbit, fractionated gamma and x-ray, 17: 31979
**NEUTRINOS**
emission in late stages of stellar evolution, effects of, 17: 32850
emission in supernova processes, electron and meson ($\mu$) associated, 17: 32880
**NEUTRON BEAMS**
collimators for, performance of reflecting multi-channel, 17: 32982
optical devices for, use at beam-hole experiments, 17: 32981
polarization measurements on fast, using scattering asymmetry, 17: 32939
production, 17: 32978
production by electron linear accelerators, parameters for, 17: 33135
production of moderated, from pulsed accelerators, 17: 32978
**NEUTRON CAPTURE CROSS SECTIONS**
tables, 17: 32709 (IFA/SN/17)
**NEUTRON DIFFRACTOMETERS**
design and operation of, 17: 32368
**NEUTRON SHIELDING**
calculation of retardation density and thermal flux in scattering medium with fast neutron source, 17: 32984
**NEUTRON SOURCES**
control of, equipment for, 17: 32344(T) (AEC-tr-5901)
description of, for activation analysis, 17: 32009
description of positive-ion accelerator for activation analysis, 17: 32330
development of cold, 17: 32980
modification of Tex generator pulsing system for lower neutron background, 17: 33126
performance of, using reaction H(t,n), 17: 33035
survey, 17: 32978
use of pulsed accelerators as, 17: 32979
use of pulsed, for measuring reactivity of critical assemblies, 17: 32894 (CONF-39-47)
yields of d-d neutrons from different targets, 17: 32768
**NEUTRON SPECTRA**
in water, energy exchange kernel calculations of, 17: 32970 (CONF-11-5)
measurement by sandwich foils, 17: 32418
measurement of, by reduction of thermal activation rates, 17: 33245 (WAPD-T-1582)
measurements of asymptotic, in multiplying media, 17: 32971 (CONF-11-6)
**NEUTRON SPECTROMETERS**
control systems for, description of automatic preprogrammed, 17: 32433
design of vertical-arm, engineering drawings for, 17: 32454
use of time-of-flight, with pulsed electron linac for pulsed photoneutron studies, 17: 33032
**NEUTRONS**
capture of, evidence for element synthesis by stellar, 17: 32883
detection and measurement of, development of semiconductor detectors for, 17: 32404(R) (WCAP-2274)
detection and measurement of, efficiency of lithium-glass scintillator for, 17: 32405 (ZFK-RN-19)
detection and measurement of, by scintillation discs, efficiency of, 17: 32406
detection and measurement of pulsed, electron linac-neutron spectrometer system for, 17: 33032
eigenfunctions and energy levels of, in nonhomogeneous nuclei, 17: 33010
interactions with alpha particles at 2–24 Mev, polarization asymmetry in elastic, 17: 32932
interactions with deuterons at 1.0 Mev, polarization in elastic, 17: 32935
interactions with deuterons, matrix elements of the Hamiltonian in, 17: 32937
photoproduction on nuclei, distributions from, 17: 33074
production in Martian atmosphere, biological implications of, 17: 32881
radiation effects on incidence of chromosomal aberrations in mice, 17: 31958
reactions (n,na) with vanadium-51, cross section for, 17: 31797(R) (BNL-782(p.51-9))
reactions with aluminum–lithium alloys, tritium production by, 17: 33110(P)
reactions with nuclei at intermediate energies, theory of, 17: 32990
reactions with nuclei, mass-flow function in, 17: 33027
reactions with nuclei, optical model for radiative capture and inelastic, 17: 33048
reactions with uranium-238, blocking effects of resonance of cross sections in, 17: 33021
scattering at low energies, quasi-elastic magnetic, 17: 32985
scattering by hydrogenous compounds, 17: 32986
scattering by nitrogen and oxygen at 14 Mev, cross sections for, 17: 33006 (UCRL-7192)
slowing down in ice at 90 and 273°K, 17: 32989
strengths of single, in nuclei, 17: 33049
thermalization in zirconium hydride, 17: 32974 (GA-4328)
thermalization of, energy-dependent Milne problem solution for, 17: 32969 (BNL-6949)
thermalization of, velocity polynomial calculation of, 17: 32973 (CONF-39-46)

thermalization of, research on, 17: 31794(R) (BNL-782(p.1-17))
transmission of, optical model coefficients for, 17: 32968(BNL-765)
**NEUTRONS, COLD**
source development, 17: 32980
**NEUTRONS, FAST**
attenuation in polyethylene slabs, 17: 32988
capture by nuclei, effects on nuclide abundances, 17: 32869
detection and measurement of, design of silicon n-p-p junction rectifier for, 17: 32411
detection and measurement, boron trifluoride-paraffin counter for, 17: 32432
detection and measurement of, using proportional counters, 17: 32445
dosimetry of, using threshold detectors, 17: 32294(T) (CEA-tr-A-1221)
effects on occurrence frequency of mutations in Drosophila, 17: 31936
effects on spleen cells in tissue culture, 17: 31946
effects on viability and chromosome aberration in potato seeds, 17: 31938
flux measurements by foil activation, 17: 33325(R) (ORNL-3445(p.251-97))
histological effects on gonads of mice, 17: 31891
polarization measurements, diffusion cloud chamber for, 17: 32422
polarization measurements on beams of, 17: 32939
scattering by tantalum-181 at 0.3 to 1.5 Mev, angular distributions and energy-level excitations in, 17: 32991 (ANL-6727)
slowing down of, solutions for equations for, 17: 32983
**NEUTRONS, FISSION**
production of in fission of nuclei, formula for average number from, 17: 33016
**NEUTRONS, PROMPT**
emission by uranium-233 fission fragments, 17: 33089
emission in uranium-235 fission at 0.4–11.3 Mev, angular and energy distributions for, 17: 33042
**NEUTRONS, THERMAL**
diffusion in water for various scattering laws, 17: 32972 (CONF-11-7)
diffusion in water as function of temperature formulas for, 17: 32976
diffusion parameters of, in water poisoned with boron or cadmium, 17: 32975
distributions in reactors, 17: 31794(R) (BNL-782(p.1-17))
flux in scattering medium, theory of, 17: 32984
polarization of, by reflection from magnetized cobalt mirror, 17: 32977
reactions (n,γ) with plutonium-239, cross section for, 17: 32723(R) (PR-P-57(p.5-20))
reactions with uranium-235 at 0.4–11.3 Mev, prompt neutron angular and energy distributions from fission, 17: 33042
scattering in magnetic crystals, theory, 17: 32987
**NEW ZEALAND**
fallout monitoring, 1963, 17: 32285(R) (DXRL-F8)
**NICKEL**
abundance in 3 Centauri A, 17: 32851
alloying effects on mechanical properties of magnesium–manganese–thorium alloys, 17: 32595
crystal structure of plastically deformed, 17: 32576 (UCRL-10778)
radiation effects on corrosion, mechanical, physical and thermal properties of, 17: 32679
separation from titanium by cation exchange chromatography, 17: 32054
**NICKEL ALLOYS**
Al–Ni–Zr, oxidation and mechanical properties, 17: 32621
Cr–Cu–Fe–Ni, radiation effects on magnetic properties of, 17: 32692
Cr–Ni, creep-rupture properties at 1300 to 1740°F, 17: 33312(R) (GEMP-215)
Cu–Ni, deposition on carbon steel tubes in feedwater heaters, 17: 32509
Fe–Mo–Ni, radiation effects on magnetic properties of, 17: 32692
Fe–Ni, radiation effects on magnetic properties of, 17: 32692
Mo–Ni–Zr, oxidation and mechanical properties, 17: 32621
Ni–Ag, production of, by sintering at 470 to 1150°C, 17: 32497
**NICKEL(II) COMPLEXES**
with tetraethylenepentamine and triethylenetetramine, dissociation and formation of, 17: 32067
with tetraethylenepentamine and triethylenetetramine, exchange reactions with nickel-63 ions, 17: 32067
**NICKEL CRYSTALS**
preparation by zone melting at 2320 to 3800°K, 17: 32590
**NICKEL ISOTOPES**
proton reactions (p,α) at 20.5 Mev on, cross sections, 17: 33070
**NICKEL ISOTOPES Ni-58**
neutron reactions (n,p) on, neutron dosimetry by, 17: 32294(T) (CEA-tr-A-1221)
proton reactions (p,γ) with, resonance yield curves for, 17: 32998 (CONF-52-3)
**NICKEL ISOTOPES Ni-59**
energy levels of, spins and transition correlations of, 17: 32725(R) (PR-P-57(p.37-43))
energy levels of, spin of, 17: 33090
**NICKEL ISOTOPES Ni-62**
energy levels of, Coulomb excitation of, 17: 32723(R) (PR-P-57(p.5-20))
neutron reactions with, determination of mass-flow function from, 17: 33027
**NICKEL ISOTOPES Ni-63**
exchange reactions with tetraethylenepentamine- and triethylene-tetramine-nickel (II) complexes, 17: 32067
**NICKEL OXIDES**
additive effects on hardness of zirconia at room temperature, 17: 32484(R) (GEAP-4284)
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
preparation of crystals of, by zone melting at 2320 to 3800°K, 17: 32590
**NICKEL STEEL**
C–Ni, radiation effects on plastic deformation of, 17: 32684
Cr–Ni, additive effects of boron on properties of, for use as reactor heat shields, 17: 33261
Cr–Ni, radiation effects on stress-rupture properties of tubular, 17: 33323(R) (ORNL-3445(p.199-217))
**NICKEL SYSTEMS**
C–Cr–Co–Ni–Ti, production of, by sintering at 470 to 1150°C, 17: 32497
C–Cr–Ni, production of, by sintering at 470 to 1150°C, 17: 32497
C–Ni–U, phase studies, 17: 32637
Ni–$ThO_2$, corrosion, oxidation, and strength of, 17: 32501
Ni–UN, phase studies, 17: 32637
**NIOBATES**
preparation and crystal structure, 17: 32100
**NIOBIUM**
alloying effects on corrosion and mechanical properties of zirconium, 17: 32484(R) (GEAP-4284)
coating of, effects of, on compression and high-temperature damage and oxidation, 17: 32526
crystal lattice dynamics of, 17: 32725(R) (PR-P-57(p-37-43))
crystal structure, 17: 32565 (ASD-TR-61-181(Pt.III))
determination by x-ray fluorescence, 17: 31999
determination in alloys, ores, and slags, fluorescence spectrometric, 17: 32007
determination in ores, spectrometric-scintillation counting, 17: 32025
fabrication of, effects of carbon and nitrogen on, 17: 32612
mechanical properties, 17: 32565 (ASD-TR-61-181(Pt.III))
mechanical properties of, effects of carbon and nitrogen on, 17: 32612
properties and separation processes for, review on, 17: 32508
recrystallization of, effects of carbon and nitrogen on, 17: 32612
reduction of concentrates and slags of, effects of carbon, iron, and silica on, 17: 32492
separation from titanium by cation exchange chromatography, 17: 32054
solubility in mercury, 17: 31798(R) (BNL-782(p.60-91))
**NIOBIUM ALLOYS**
analysis for cerium, photometric, 17: 32021
composition, corrosion resistance, and mechanical properties of, review on, 17: 32508
Cr–Nb, creep and tensile properties, 17: 32568 (CONF-53-5)
Cu–Nb, preparation and properties of impregnated, 17: 32495
Mo–Nb–W–Zr, mechanical properties of warm-extruded and rolled, 17: 32567 (BMI-X-249)
Nb–Ag, preparation and properties of impregnated, 17: 32495
Nb–Pt, lattice parameters and solubility of intermetallic compounds $PtNb_3$ and $PtNb_2$ in, 17: 32638
Nb–Sn, physical properties of gas-phase-deposited $Nb_3Sn$, 17: 32647
Nb–Sn, properties as superconducting magnet, 17: 32712 (LNF-63/26)
$Nb_3Sn$, superconducting critical fields of, 17: 32224

Nb–Sn, superconductivity properties of $Nb_3Sn$ in, 17: 32615
Nb–Th, superconducting properties of eutectic, 17: 32650
Nb–V, creep and tensile properties, 17: 32568 (CONF-53-5)
Nb–V, machinability, properties, weldability, and workability of, 17: 32581
Nb–Zr, corrosion resistance and tensile properties of welds in, 17: 32496
Nb–Zr, corrosion hydrogen embrittlement of, 17: 32525
Nb–Zr, creep and tensile properties, 17: 32568 (CONF-53-5)
Nb–Zr, effects of environment, heat treatment, and temperature on corrosion of, 17: 32524
Nb–Zr, preparation and properties of heat-treated, 17: 32626
Nb–Zr, properties as superconducting magnet, 17: 32712 (LNF-63/26)
Nb–Zr, resistance to sodium corrosion, 17: 31798(R) (BNL-782(p.60-91))
Nb–Zr, superconducting critical fields of, 17: 32224

**NIOBIUM CARBIDES**
thermal decomposition, 17: 32036 (CONF-40-2)
NbC–UC, carbon-stable regions in, 17: 32617

**NIOBIUM FILMS**
crystallite nucleation by electron-beam heating in, 17: 32489

**NIOBIUM IONS**
spectra of, in hydrofluoric acid solutions, infrared and Raman, 17: 32070

**NIOBIUM ISOTOPES Nb-93**
neutron radiative capture in, optical model for cross sections of, 17: 33048

**NIOBIUM ISOTOPES Nb-95**
determination in seaweed and sea water, spectrometric, 17: 32005

**NIOBIUM OXIDES**
determination by x-ray fluorescence, 17: 31999
preparation and crystal structure of ternary, 17: 32100

**NIOBIUM STEEL**
composition, corrosion resistance, and mechanical properties of, review on, 17: 32508

**NIOBIUM SYSTEMS**
Fe–Nb–Si, effects of carbon content on properties and reduction of, 17: 32492

**NITRIC ACID**
radiation effects on vapor phase reactions with propane, temperature dependence of gamma, 17: 32175
solvent properties for scandium nitrates, 17: 32115
solvent properties for aluminum, iron, thorium, and uranium, 17: 32194(R) (TID-19068)
solvent properties for elements, 17: 32194(R) (TID-19068)
vapor phase composition, effect of nitrates, 17: 33400
$Al(NO_3)_3$–HF–$HNO_3$, corrosive effects on type 304L stainless steel and zirconium, 17: 32192(R) (DP-839)
HF–$HNO_3$, corrosive effects on stainless steel containing boron-10, 17: 32517 (RFP-307)

**NITRILES**
radiation effects on, cosmic, 17: 32693

**NITROGEN**
alpha reactions ($\alpha$,n) with, neutron yields from, 17: 33017
atomic wave functions for, with five parameters, 17: 32796
boiling in, liquid-solid interface effects on nucleation characteristics in, 17: 32828
content in rabbit blood during radiation sickness, effects of glycocoll and peptone on, 17: 31975
crystal structure of, isotopic effects on unit-cell volumes, 17: 32106
effects on mechanical properties of niobium, 17: 32612
electric conductivity of cesium-seeded plasma of, near thermal equilibrium, 17: 33216
electron avalanche growth in, visible discharge in, 17: 32786
electron recombination with oxygen ions in presence of, rate for three-body, 17: 32816
electron temperature in plasma afterglow of, gated microwave radiometer for, 17: 33217
heat of desorption, 17: 33159(R) (ORNL-3472(p.107-18))
helium- and hydrogen-ion reactions with ionization cross sections for, 17: 32771
helium ion interactions at 0.133 to 1 Mev, free electron and ion production in, 17: 32731 (TID-19137)
microwave gyro-interactions in magneto-plasma of, electron cyclotron resonance absorption of energy from, 17: 33215
neutron scattering cross sections at 14 Mev, 17: 33006 (UCRL-7192)
nitrogen ion bombardment of, optical excitation in, 17: 32707 (CONF-46-43)
plasma jets of, characteristics of pinch, 17: 33196
plasma jets of, electric current and field distribution in, 17: 33203
plasma jets of, performance of coaxial, 17: 33207
plasma of, acceleration, 17: 33192
reactions with uranium carbide and uranium-carbon-oxygen systems, 17: 32486(R) (NCSC-2663-13)
shock waves in, radiation behind, 17: 32705 (BSD-TDR-63-102)

**NITROGEN IONS**
reactions with nitrogen, optical excitation in, 17: 32707 (CONF-46-43)

**NITROGEN ISOTOPES N-13**
energy levels of, excitation functions for ground and 3.5-Mev, 17: 33044

**NITROGEN ISOTOPES N-14**
deuteron scattering at 0.7–2.1 Mev, angular distributions and cross sections for, 17: 33086
formation in tissue, by proton activation, 17: 31851 (BNL-6989)
reactions ($N^{14}$,5n) with cesium-133 at 79.8 and 105.4 Mev, samarium-142 recoil range from, 17: 33094

**NITROGEN ISOTOPES N-15**
separation from other nitrogen isotopes by chemical exchange, mass transfer in, 17: 32470

**NITROGEN ISOTOPES N-16**
beta decay of, G invariance in, 17: 33095

**NITROGEN SYSTEMS**
C–N–U, thermodynamics of formation of $UC_{1-x}N_x$ in, 17: 32132

**NITROGEN TRITIDES**
spectra of, vibrational bands in infrared, 17: 32048 (TID-19213)

**NITROSYL CHLORIDES**
reactions with hydrofluoric acid, NOF · 3.1 HF production in, 17: 31795(R) (BNL-782(p.18-43))

**NITROSYL COMPOUNDS**
volatility, 17: 31795(R) (BNL-782(p.18-43))

**NITROSYL FLUORIDES**
NOF · 3.1 HF, properties as solvent for uranium(IV) oxides, 17: 31795(R) (BNL-782(p.18-43))

**NITROUS ACID**
mutagenic effects in Aspergillus, ascospore color, 17: 31893

**NOISE**
discrimination against, in nuclear magnetic resonance spectra by continuous averaging, 17: 32363
production of acoustic, in nucleate boiling, 17: 32251 (TRG-Report-549)

**NORTH CAROLINA**
hydrographic, sediment, and faunal survey of Bogue Sound area, 17: 31817(R) (TID-19122)

**NORTHERN RHODESIA**
uranium minerals in, age of, 17: 32265

**NORWAY**
monitoring of atmospheric cesium-137 in, during Oct. 1937, 17: 32275

**NPD REACTOR**
description, commissioning, and early operation, 17: 33359
operating experience from June 1962 to March 1963, 17: 33337
personnel training program for, 17: 33343

**NRX REACTOR**
in-pile loop operation for organic-coolant studies in, 17: 32662 (CRFD-1132)

**NUCLEAR BATTERIES**
description of, for space power uses, 17: 33391

**NUCLEAR CHEMISTRY**
book: *Nuclear Chemistry*, 17: 32815

**NUCLEAR EMULSIONS**
alpha track profiles in, 17: 32888
charged-particle multiple scattering in, 17: 32931
preparation of, with very fine granulation, 17: 32407
proton interactions with nucleons in, effective target mass distribution for 28-Bev, 17: 32965
proton reactions with, deuteron, helium-3 and triton production in, 17: 33091
proton scattering at 6.2 Bev in, 17: 32907 (NYO-10271)
use for thorium determinations, 17: 31988(T) (CEA-tr-A-1197)

**NUCLEAR ENGINEERING**
developments at Brookhaven, 17: 31793(R) (BNL-782)
**NUCLEAR MAGNETIC RESONANCE**
Knight shifts of boron-11, in metal hexaborides, 17: 32083
measurement in very weak magnetic fields, 17: 32390
measurement of, magnetic field inhomogeneity compensation in spectrometer for, 17: 32367
of metals, 17: 32569 (CONF-54-1)
spectra of, use of Overhauser effect in analysis of high resolution, 17: 32129
spectroscopy, improvement of signal-to-noise ratio by continuous averaging in, 17: 32363
**NUCLEAR MODELS**
superconducting, use for describing residual interactions in shell model, 17: 33064
**NUCLEAR MODELS (COLLECTIVE)**
Coulomb excitation with heavy ions, multiple, 17: 33087
use for describing residual interactions in shell model, 17: 33064
**NUCLEAR MODELS (DROP)**
fission calculations by, 17: 33009(T) (UCRL-Trans-978)
variational problems in superfluid, projection operators for, 17: 32738
**NUCLEAR MODELS (OPTICAL)**
book: *The Optical Model in Nuclear and Particle Physics*, 17: 33108
neutron inelastic scattering and radiative capture in, cross sections for, 17: 33048
neutron transmission in, 17: 32968 (BNL-765)
**NUCLEAR MODELS (SHELL)**
description of, with collective and superconducting corrections, 17: 33064
negative parity states in (2s,1d) shell, 17: 33092
nucleon interactions in oxygen isotopes, effective, 17: 33100
wave function calculations, 17: 32930
**NUCLEAR PARTICLES**
interactions at high energies, models for, 17: 32952
**NUCLEAR PHYSICS**
book: *Introductory Nuclear Reactor Theory*, 17: 33266
calculation of retardation density and thermal flux in scattering medium with fast neutron source, 17: 32984
research in hypernuclear, future, 17: 32901 (EFINS-63-32)
research progress at Chalk River, 17: 32722(R) (PR-P-57)
use of multiparameter analyzers in, 17: 32348
**NUCLEAR POWER**
Canadian, fabrication of stainless steel fuel chambers for, 17: 33333
economic analysis of binary cycle using steam and Freon-12, 17: 33351
economic aspects in electric utility systems, 17: 33348
economics of, influence of steam-cycle performance on, 17: 33356
research in Rumania, 17: 31811
**NUCLEAR POWER PLANTS**
condenser for boiling-water, performance of air-cooled, 17: 33303 (CEND-139)
description and cost analysis of 1800-Mw(e) heavy-water, 17: 33332
design and cost estimates to 4-unit heavy-water, 17: 33360
development of Garigliano station for increased power output, quarterly summary No. 3, 17: 33311 (GEAP-4306)
economic analysis of heavy water-moderated, 17: 33331
economic aspects, 17: 33334
economic aspects in electric utility systems, 17: 33348
economics and evaluation of nuclear defense capabilities of, 17: 33361
operating experience of Kahl station from 1961 to 1963, 17: 33338
optimization of preheating temperature of feed water for, 17: 33329
personnel training program for NPD, 17: 33343
superheat-reheat programs and concepts, review of, 17: 33353
**NUCLEAR REACTIONS**
bibliography on research on, at Hungarian Academy of Sciences, 17: 31810
book: *The Optical Model in Nuclear and Particle Physics*, 17: 33108
cross sections near thresholds, in attractive Coulomb fields, 17: 33083
direct, theory for cross sections of, 17: 33085
directional correlation measurements, variances in, 17: 33031
energy level reduced neutron width determination by, 17: 33066
gamma angular distribution analysis, calculation of coefficients for, 17: 33033
models for high-energy, comparisons between, 17: 32952
mutual excitation, semi-classical treatment of, 17: 33022
products of, continuous chamber for observing, 17: 32393(P)
rates of, cross sections for calculating, 17: 32994 (CONF-39-37)
theory of, statistical, 17: 32727(R) (PR-P-57(p.69-85))
yield curves for, atomic effects on, 17: 32998 (CONF-52-3)
**NUCLEAR STRUCTURE**
measurement of nuclear matter distribution by meson ($\pi^0$) photoproduction, 17: 33106
parity states in (2s,1d) shells, negative, 17: 33092
**NUCLEAR TECHNOLOGY**
conference on, France-Japan, Nov. 12 to 14, 1962, 17: 33267
magnet pole shaping for strong- and weak-focusing fields, 17: 32791
**NUCLEAR THEORY**
collective effects and elastic scattering from odd-mass nuclei, 17: 33051
description of high-energy interactions in, 17: 32952
energy levels in a square well with hard core, 17: 33001 (CONF-128-1)
reaction cross sections near thresholds, Coulomb-field effects on, 17: 33083
strong and weak interactions of bound Λ particles, 17: 32900 (EFINS-63-29)
**NUCLEI**
alpha decay of, alpha-gamma angular correlations in, 17: 32446
beta decay of, induced effects in, 17: 33095
collective effects and elastic scattering from odd-mass, 17: 33051
contents in reactors, computer determination of, 17: 33244 (ORNL-TM-361(Add.))
deuteron reactions (d,d) and (d,p) and proton scattering on, angular distributions and polarizations for, 17: 33036
deuteron reactions (d,p) with, Coulomb interaction effects in, 17: 33067
electron reactions with, cross sections for meson ($\pi$) production in, 17: 32913 (TID-7668(Sect.V))
energy level density in, high-angular momentum cut-off in, 17: 32999 (CONF-62-7)
energy levels of, determination of reduced neutron widths of, 17: 33066
energy levels of, model for resonance, 17: 33001 (CONF-128-1)
gamma absorption and emission processes in, projection operator formalism for, 17: 33013
gamma internal conversion coefficients at threshold in, Coulomb field effects on K-shell, 17: 33047
gamma Mössbauer spectra in infinite crystals, 17: 33084
gamma resonance reactions with, methods for studying, 17: 33034
ion reactions with, multiple Coulomb excitation from heavy, 17: 33087
neutron capture by, effects on nuclide abundances, 17: 32869
neutron reactions at intermediate energies, theory of, 17: 32990
nucleon distributions in, analysis by meson ($\pi^0$) photoproduction on, 17: 33073
nucleon reactions on, models for inelastic, 17: 33064
parity states in (2s,1d) shell of, shell model study of negative, 17: 33092
photon reactions with, proton distributions from, 17: 32440
properties of, methods for calculating, 17: 32727(R) (PR-P-57(p.69-85))
reactions of heavy, at 5000 Bev, 17: 32893
reactions on, effects of Coulomb field on cross sections, 17: 33083
reactions on, theory for cross sections of direct, 17: 33085
rotation bands in odd-mass, decoupling effect and odd-even shift in, 17: 33046
shell structure and Roche nuclear density, 17: 33010
spectra of cosmic, at 3260 m altitude, 17: 32892
**NUCLEI (CELLS)**
incorporation of tritium labeled amino acids into, in mice, 17: 31887
**NUCLEONICS**
book: *Experimental Nucleonics*, 17: 32455
**NUCLEONS**
distributions in nuclei, analysis by meson ($\pi^0$) photoproduction on, 17: 33073
form factors, 17: 32909 (TID-7668(Sect.I))
interactions in oxygen isotopes, model for effective, 17: 33100
interactions with hyperons (Λ), structure of weak, 17: 32903 (EFINS-63-39)
interactions with photons, electron pair production in, 17: 32711 (LNF-62/113)

interactions with mesons ($\pi$), partial wave amplitudes for, 17: 32899 (CONF-46-80)
interactions with mesons ($\pi$) at ≤ 3 Bev, strange particle production cross sections in, 17: 32920
interactions with mesons ($\pi^-$) at 6.8 and 8.0 Bev/c, hyperon ($\Xi^-$) production in, 17: 32945
interactions with deuterons, phase-shift ambiguities in, 17: 32946
interactions with mesons ($\pi$) at low energy, S-wave dispersion relation in, 17: 32949
interactions with photons, amplitude for, 17: 32962
interactions with protons at 28 Bev, effective target mass distribution for, 17: 32965
interactions with photons, model for resonance state production in, 17: 32966
parity and spin of, 17: 32941
quaternion description of, formulation of, 17: 32716(R) (NP-12996(p.23-8))
reactions on nuclei, models for inelastic, 17: 33064

**NUCLEOPROTEINS**
radiation effects on content of, in organs and tissues in chickens, 17: 31955

**NUCLEOTIDES**
radiation effects on metabolism of, in lymph system, tracer study of, 17: 31932

**NUTRIENTS**
effects on radiation effects on metabolic processes in rats, 17: 31838

# O

**OCEANOGRAPHY**
of Bogue Sound area, North Carolina, 17: 31817(R) (TID-19122)
radioisotope distributions in oceans, vertical, 17: 32273

**OPTICAL SYSTEMS**
development of glass-fiber, for fluoroscopy, 17: 31822

**ORES**
analysis for niobium and tantalum, fluorescence spectrometric, 17: 32007

**ORGANIC COMPOUNDS**
analysis for arsenic using oxygen flask technique, 17: 32003
heat-transfer properties of liquid, as reactor coolants, 17: 32254
purification of labeled, design of noncontaminating gas liquid chromatographic system for, 17: 32140
radiation and thermal stability, 17: 32156
solvent properties for plutonium, literature survey on, 17: 32190 (DP-700)
synthesis of carbon-14-labeled, using a vacuum technique, 17: 32150
vapor-pressure measurement of, method and apparatus for, 17: 32391(P)

**ORGANIC COMPOUNDS, METALLO-**
promotion of radiation effects on polymers by, 17: 32700(P)

**ORGANIC COOLED REACTORS**
development at Brookhaven, 17: 31794(R) (BNL-782(p.1-17))

**ORGANS**
radiation protection of sensitive, during cobalt-60 therapy, 17: 31823

**ORNL GAS COOLED REACTOR (GCR-3)**
coolants for, comparison of, 17: 33325(R) (ORNL-3445(p.251-97))
power cycle performance of, effects of feedwater temperature on, 17: 33325(R) (ORNL-3445(p.251-97))

**ORNL RELATIVISTIC ISOCHRONOUS CYCLOTRON**
information guide for users of, 17: 33118 (ORNL-TM-643)

**ORNL RESEARCH REACTOR**
control rod calibration for, by rod-drop method, 17: 33374 (ORNL-TM-605)

**OSMIUM ISOTOPES Os-186**
energy levels of, rotational excitation of first-excited, 17: 33015

**OSMIUM ISOTOPES Os-188**
energy levels of, rotational excitation of first-excited, 17: 33015

**OXIDATION**
of metal foils, study by beta spectroscopy using xenon-125, 17: 32532

**OXYGEN**
alpha reactions ($\alpha$,n) with, neutron yields from, 17: 33017
alpha reactions ($\alpha$,n) with, neutron yields from, 17: 33018
atomic wave functions for, with five parameters, 17: 32796
balance in man, effects of cystamine and S-beta-amino ethylisothiuronium on, 17: 31833
determination in americium, plutonium, and thorium, activation, 17: 31992
determination in coal by nuclear techniques, 17: 31985 (CONF-124-1)
determination of, activation, 17: 32022
diffusion in bcc metal crystals, 17: 32618
diffusion in hafnium at 800 and 950°C, 17: 32601
diffusion in thorium dioxide, 17: 32564 (ASD-TDR-63-635)
electron avalanche growth in, visible discharge in, 17: 32786
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
helium ion interactions at 0.133 to 1 Mev, free electron and ion production in, 17: 32731 (TID-19137)
microwave gyro-interactions in magneto-plasma of, electron cyclotron resonance absorption of energy from, 17: 33215
neutron scattering cross sections at 14 Mev, 17: 33006 (UCRL-7192)
radiosensitivity effects on seeds, 17: 31869
radiosensitivity effects on plants, 17: 31951
recombination with hydrogen in water-boiler reactors, catalytic, 17: 33297(P)
x-ray yields from electron bombardment of, K, 17: 32789

**OXYGEN ION BEAMS (O-16)**
reactions with hydrogen, anion production in, 17: 32723(R) (PR-P-57 (p.5-20))

**OXYGEN IONS**
electron recombination in presence of nitrogen atoms, rate for three-body, 17: 32816
production in cation beam reactions with hydrogen, 17: 32838

**OXYGEN ISOTOPES O-16**
alpha elastic and inelastic scattering at 22.5 Mev, differential cross sections for, 17: 33101
energy level mixing in, giant-resonance, 17: 33004 (NP-12986)
energy levels of, negative parity states for, 17: 33092
energy levels of, spin assignments for, 17: 33012
formation in tissue, by proton activation, 17: 31851 (BNL-6989)
gamma reactions with, study of giant resonance in, by electron inelastic scattering, 17: 33052
neutron strengths in, single, 17: 33049
reactions ($O^{16}$,$\alpha\gamma$) with beryllium-9 at 24 Mev, neon-21 energy level lifetimes from, 17: 33098

**OXYGEN ISOTOPES O-17**
energy levels of, negative parity states for, 17: 33092
neutron strengths in, single, 17: 33049
nucleon interactions in, model for effective, 17: 33100

**OXYGEN ISOTOPES O-18**
energy levels of, negative parity states for, 17: 33092
energy levels of, spin assignments for, 17: 33012
nucleon interactions in, model for effective, 17: 33100

**OXYGEN ISOTOPES O-19**
nucleon interactions in, model for effective, 17: 33100

**OXYGEN ISOTOPES O-20**
nucleon interactions in, model for effective, 17: 33100

**OXYGEN SYSTEMS**
C–O–U, fabrication and properties of sintered, 17: 32486(R) (NCSC-2663-13)
C–O–U, phase studies, 17: 32486(R) (NCSC-2663-13)
C–O–U, reactions with nitrogen, 17: 32486(R) (NCSC-2663-13)
C–O–U, thermodynamics of formation of $UC_{1-x}O_x$ in, 17: 32132
He–$O_2$, free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
Hf–O, crystal structure and thermodynamic properties at 0 to 25 at.% oxygen, 17: 32630

# P

**PACKAGE POWER REACTORS**
design of unmoderated europium-poisoned gas-cooled, 17: 33313 (IDO-28584(Add.1))

**PALLADIUM ALLOYS**
Be–Pd, wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445(p.199-217))
Pd–$U^{235}$, development, 17: 31796(R) (BNL-782(p.44-50))

**PALLADIUM ISOTOPES Pd-105**
energy levels of, gamma-gamma coincidence spectra for, 17: 33028

**PAPER**

industrial research on, use of tracers in, 17: 32328
**PARAFFIN**
shielding properties of, 17: 33256
**PARTICLE TRACKS**
analysis in emulsion, ionization-momentum relations for, 17: 32453
location in multi-wire spark detectors, accuracy of, 17: 32443
**PARTICLE TRAJECTORIES**
determination in electron microscopes, caustic and shadow image patterns for, 17: 32346
determination in magnetic mirror systems, 17: 33165
**PARTICLES**
scavenging of sorbed material from mineral, tracer study, 17: 31830 (TID-19127)
size and size distribution measurement using radiation, 17: 32842(P)
**PEACH BOTTOM POWER REACTOR**
design and performance capabilities of, 17: 33330
development of, Oct. 1–Dec. 31, 1962, 17: 33308(R) (GA-4247)
**PEGMATITES**
ages of minerals from Rwanda-Urandi, 17: 32268
**PENNSYLVANIA**
fallout monitoring in Pittsburgh area, 1963, 17: 32288 (NSEC-91)
**2,4-PENTANEDIONE COMPLEXES**
separation by gas chromatography, 17: 32068
**2,4-PENTANEDIONE, HEXAFLUORO-**
complexes of, separation by gas chromatography, 17: 32068
**2,4-PENTANEDIONE, TRIFLUORO-**
complexes of, separation by gas chromatography, 17: 32068
**2-PENTANONE**
solvent properties for thorium and uranium, 17: 32194(R) (TID-19068)
**3-PENTANONE**
solvent properties for thorium and uranium, 17: 32194(R) (TID-19068)
**PENTOBARBITAL SODIUM**
effects on enzymatic activity of irradiated pepsin, 17: 31940
**PEPSIN**
radiation effects on proteolytic activity of, effects of radioprotective compounds on, 17: 31940
**PEPTIDES**
radiation effects on, ultraviolet thermoluminescence and electron paramagnetic resonance of, 17: 31850 (AD-294395)
**PEPTONES**
effects on ammonia and nitrogen content in rabbit blood during radiation sickness, 17: 31975
**PERTURBATION THEORY**
description of high-energy interactions in, 17: 32952
dispersion relations for pseudoscalar-meson scattering, 17: 32951
scattering amplitudes in, Regge-pole effects on asymptotic, 17: 32957
scattering by potential wells in, Regge-pole effects on, 17: 32956
use for calculation of optimum distribution of reactor materials, 17: 33237 (AE-110)
vector mesons as Regge poles in, 17: 32902 (EFINS-63-35)
**PHANTOMS**
analysis for phosphorus-32 distribution, radiometric, 17: 31876
design of, with changeable cross section, 17: 31823
**PHARMACEUTICALS**
effects of, on protective effects of pressor amidines against radiation damage to mice, 17: 31948
**PHASE STUDIES**
transitions of the second kind, pressure effects on, 17: 32806
**PHENOTHIAZINE, 3-CHLORO-10-(3'-DIMETHYLAMINOPROPYL)-**
protective effects against radiation injury of gastrointestinal tract, 17: 31896
**PHENYL BORATES**
tetra-, analytical use for determination of alkali metals by potentiometric titration, 17: 31998
**PHOSPHATASES**
radiation effects from injected plutonium-239 on activity of, in bone, 17: 31926
**PHOSPHATE GLASS**
fission fragment tracks in, preferential chemical dissolution for, 17: 32696
**PHOSPHATES**
pyridoxal, radiation effects on content and production in *E. coli* of, 17: 31960
radiation effects on organic, cosmic, 17: 32693
**PHOSPHINES**
triphenyl-, reactions with uranium tetrachlorides, 17: 32064
**PHOSPHORIC ACID**
oxidation of zirconium, anodic current strength in, 17: 32528
**PHOSPHORS**
luminescence of organic, decay of slow component of, 17: 32426
trap properties of electroluminescent zinc sulfide, 17: 32834
**PHOSPHORUS**
alpha reactions ($\alpha$,n) with, neutron yields from, 17: 33017
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
**PHOSPHORUS ISOTOPES P-32**
determination of distribution in phantoms and patients, radiometric, 17: 31876
effects of beta particles from injected, on mineral and protein metabolism in calcifying tissues, 17: 31925
incorporation into colloidal chromium phosphate for medical use, 17: 32075
production in carbon-13 reactions ($C^{13}$,$\gamma$) with fluorine-19, yields from, 17: 33060
separation from organic reactor coolants, by adsorption, 17: 33280
therapeutic effects on leukemic forms in chickens, 17: 31825
**PHOSPHORUS OXIDES**
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
**PHOTOELECTRIC EFFECT**
theory of extremely relativistic, 17: 32810
**PHOTOGRAPHIC EMULSIONS**
charged particle tracks in, ionization-momentum relations for, 17: 32453
**PHOTOGRAPHIC FILM DETECTORS**
sensitivity for low-level gamma dosimetry, 17: 32457
sensitivity of Fuji film badge to beta rays, 17: 32414
**PHOTOMESONS**
production of $\pi^0$, on nuclei, 17: 33073
**PHOTOMULTIPLIER TUBES**
description of, for scintillation uses, 17: 32451
properties of, device for measuring, 17: 32335 (DESY-A2.99)
time resolution characteristics of, 17: 32371
use for distinguishing and counting charged particles from magnetic analyzers, 17: 32428
**PHOTONS**
interactions with nucleons, model for resonance state production in, 17: 32966
interactions with electrons, relativistic photoelectrons from, 17: 32810
interactions with nucleons, electron pair production in, 17: 32711 (LNF-62/113)
interactions with mesons ($\pi$), nucleons, and photons, amplitudes for, 17: 32962
interactions with protons, production of mesons ($\pi^+$) in, 17: 32964
production of polarized, in electron beam-laser beam interaction, 17: 32914 (TID-7668(Sect.VI))
quantum Green's function for, effects of virtual $\pi$ mesons on, 17: 32955
reactions with hydrogen, cross sections for ionization in, 17: 33155(R) (ORNL-3472(p.56-69))
reactions with nuclei, proton distributions from, 17: 32440
reactions with plasma, effects on bremsstrahlung emission rate from, 17: 33177
**PHOTOPROTONS**
distributions of, telescope for detecting, 17: 32440
**PHTHALIC ANHYDRIDE**
radioinduced polymerization of unsaturated esters of, with styrene, 17: 32177
**PHYSICAL CONSTANTS TESTING REACTOR**
operation of, manual for, 17: 33367 (HW-69714)
**PHYSICS**
developments at Brookhaven, 17: 31793(R) (BNL-782)
research at Naval Research Laboratory, 17: 32714(R) (NP-12996)
research at ORNL, thermonuclear, 17: 33150(R) (ORNL-3472)
research programs of UKAEA, ninth annual summary, 17: 31800(R) (NP-12981)
research progress at Chalk River, 17: 32722(R) (PR-P-57)

**PICOLINES**
2,6-di-t-butyl-4-, effects of tritiated water on, in presence of ammonium chloride, 17: 32142
**PINCH DEVICES**
design for producing high-temperature high-density plasma, 17: 33220(P)
plasma magnetic field measurements in Scylla I theta, 17: 33178
plasma rotation in theta, 17: 33163
**PINCH EFFECT**
electron temperature in theta, from impurity line radiation, 17: 33214
plasma acceleration by, electric current and field distribution in, 17: 33203
plasma acceleration by, characteristics of, 17: 33196
plasma acceleration by, snowplow model for performance of, 17: 33197
**PIPES**
fission-product deposition from gas streams in, 17: 33243 (ORNL-3379)
**PISTON ENGINES**
cylinder and ring wear in, tracer analysis of, 17: 32226
**PITCHBLENDES**
age of, in Katanga and N. Rhodesia, 17: 32265
**PLANETS**
cosmic and solar flare radiation interactions with Martian atmosphere, biological implications of neutron production in, 17: 32881
cosmic proton reactions on planetesimals, helium-3 from, 17: 32866
magnetic field parameters of, 17: 32879
**PLANKTON**
beta activity of, in Adriatic and Ligurian Seas, May 1961 to Nov. 1962, 17: 31845
$^{208}$-, beta radioactivity of, in Black Sea, 17: 31843
**PLANT CELLS**
radiation effects, 17: 31881
**PLANTS**
fission product metabolism, factors affecting biological availability, 17: 31840
iodine-131 contamination of, after stack release, 17: 32284 (DPSPU-30-63-26B)
radiation effects on, environmental factors in, 17: 31951
radiosensitivity, 17: 31816(R) (ORO-605)
radiosensitivity of *Lemna minor*, 17: 31873
radiosensitivity of, relation of chromosome number and nuclear volume to, 17: 31949
uptake of ambient radioisotopes, survey, 17: 32276
**PLASMA**
acceleration by displacement currents from ionization, 17: 33206
acceleration in coaxial guns, 17: 32225
acceleration in crossed fields, three-fluid analysis of, 17: 33210
acceleration of, in pulsed, single-phase, inductive devices, 17: 33192
acceleration of, using superconducting magnets, 17: 32224
analysis of argon, time-of-flight mass spectrometer for, 17: 33213
bremsstrahlung emission rate in dense, photon reaction effects on, 17: 33177
containment of, magnetic end closures for devices for, 17: 33221(P)
containment of, one-dimensional theory of r-f, 17: 33180
diffusion across magnetic fields in, 17: 33190
diffusion and properties in Stellarator (B-3), 17: 33145 (MATT-157)
discharge of, parametric oscillations and harmonic generation in, 17: 33162
electric conductivity measurement in seeded argon, 17: 33209
electric conductivity of cesium-seeded, near thermal equilibrium, 17: 33216
electric discharge in weakly ionized column of, instability of Penning, 17: 33176
electric impedance of electrodes immersed in moving, 17: 33164
electromagnetic radiation in compressible, radiation from, 17: 33141 (AD-410077)
electromagnetic wave transmission through slabs of, in magnetic field, 17: 33218
electromagnetic wave reflection by, 17: 33181
electromagnetic wave propagation in, nonlinear theory of, 17: 33185
electron beam interactions with ions in warm, magnetic field effects on energy gain in, 17: 33194
electron beam production in, by hollow cathode discharge, 17: 32822
electron-ion correlations in nonisothermal, 17: 33182
electron temperature in theta pinch in, from impurity line radiation, 17: 33214
electron temperature in afterglow of, gated microwave radiometer for, 17: 33217
electron temperatures in, 17: 33154(R) (ORNL-3472(p.50-5))
energy levels of one-electron atoms and ions in high-temperature, 17: 33191
heating of, by electron beam-plasma interactions, 17: 33153(R) (ORNL-3472(p.24-49))
heating of dense moving, using r-f fields, 17: 33211
instabilities in, effects on solar flare production, 17: 33166
interactions of two different, electron density perturbations in, 17: 33193
interactions with geomagnetically trapped particles, vlf radiation from, 17: 32868
ion temperatures in PIG reflex, measurements of, 17: 33168
magnetic field measurements of, in Scylla I theta pinch, 17: 33178
magnetohydrodynamic flow in crossed-field accelerators for, insulator boundary layer effects on, 17: 33201
microwave gyro-interactions in magneto-, electron cyclotron resonance absorption of energy from, 17: 33215
oscillations in bounded, nonlinear Landau damping of, 17: 33169
oscillations in cylindrical, long-wavelength electron, 17: 33144 (D1-82-0255)
oscillations in external electric field, quasi-linear theory of, 17: 33179
oscillations in low-pressure inhomogeneous, 17: 33189
oscillations in one-dimensional, Landau damping in, 17: 33171
oscillations of, in external electric field, 17: 33172
particle correlation functions for unstable, two-body, 17: 33173
performance of cesium- and lithium-seeded, in magnetohydrodynamic cells 17: 32817
production of high-temperature high-density, device for, 17: 33220(P)
properties of DCX-2, 17: 33152(R) (ORNL-3472(p.9-23))
properties of deuterium arc, 17: 33154(R) (ORNL-3472(p.50-5))
properties of electron-cyclotron, 17: 33153(R) (ORNL-3472(p.24-49))
properties of nonequilibrium monatomic, calculation of, 17: 33208
radio wave interactions with, electric wave production by, 17: 33186
radio wave propagation through cylindrical sheaths of, 17: 33202
research programs on, ninth annual summary of UKAEA, 17: 31800(R) (NP-12981)
resonances in cold, effects of wave-propagation direction on, 17: 33148 (NASA-TN-D-1875)
rotation of, in theta pinch, 17: 33163
stability in a-c positive column in a magnetic field, 17: 33161 (UCRL-10698)
stability in infinite collisionless, magnetic field effects on h-f electrostatic, 17: 33195
stability in magnetic mirror machines, 17: 33151(R) (ORNL-3472(p.1-8))
stability in multipolar systems of, effect of resistivity on hydromagnetic, 17: 33175
stability in reflex discharge, 17: 33147 (MATT-198)
stability of, in time-dependent magnetic field, 17: 33142 (D1-82-0218)
stability of inhomogeneous, in strong magnetic fields, 17: 33188
stability of, quasi-linear theory of, 17: 33146 (MATT-169)
stability of, theory, 17: 33157(R) (ORNL-3472(p.75-83))
velocity distribution in unstable, kinetic equation for, 17: 33167
wave excitation by grid pair in collisionless, 17: 33183
wave instabilities in counterstreaming collisionless, longitudinal and transversal, 17: 33200
wave propagation in magneto-, microwave-cavity measurement of Faraday effect in, 17: 33198
wave propagation in, nonlinear transverse, 17: 33199
waves in relativistic, nonlinear stationary, 17: 33170
waves in, relaxation effects on two-component, 17: 33174
whistler propagation in, thermal cutoff for, 17: 33143 (D1-82-0229)
**PLASMA JETS**
acceleration in crossed fields, three-fluid analysis of, 17: 33210
description of pulsed, single-phase, inductive, 17: 33192
design for space propulsion uses, 17: 32225
development of, using displacement currents from ionization, 17: 33206
electric current and field distribution in pinch, 17: 33203

electron cyclotron resonance as energy source in, 17: 33204
fluid flow in crossed-field, insulator boundary layer effects on, 17: 33201
performance of coaxial, 17: 33207
performance of crossed-field, using monatomic gases, 17: 32835
performance of Hall current, 17: 33205
performance of pinch, snowplow model for, 17: 33197
properties of pinch, 17: 33196
propulsion systems of, satellite raising and orbit transfer parameters for, 17: 32219

**PLASTICS**
bibliography on composites, 17: 32482 (AD-408618)
physical properties of, effects of composition, environment, ionization, and radiation on, 17: 32683
radiation effects on, cosmic, 17: 32693
shielding properties of, 17: 33256

**PLATES**
fabrication incorporating a temperature-measuring device, 17: 33287(P)
heat transfer in forced convection between paralleled, 17: 32256

**PLATINUM**
properties of, for use in thermocouples, mechanical and thermoelectric, 17: 32644

**PLATINUM ALLOYS**
Nb–Pt, lattice parameters and solubility of intermetallic compounds $PtNb_2$ and $PtNb_3$ in, 17: 32638

**PLATINUM ISOTOPES**
proton reactions (p,α) at 20.5 Mev on, cross sections for, 17: 33070

**PLOWSHARE PROJECT**
blast propagation from Sedan underground explosion, 17: 31801 (PNE-202F)
distribution of ejecta on ground surrounding a nuclear crater, 17: 31802 (PNE-217F)
production of transuranium elements in a thermonuclear explosion in, 17: 32733 (UCRL-7314(Rev.I))
slide-dam construction employing nuclear explosions, 17: 32209 (SC-4781(RR))

**PLUTONIUM**
analysis for oxygen, activation, 17: 31992
critical masses and volumes of solutions of, 17: 32895 (HW-SA-2999)
development of reactor recycle programs for, 17: 33240(R) (GEAP-4303)
electrorefining of commercial, by chloride and fluoride salt baths, 17: 32499
fabrication of, design of Plutonium Fabrication Pilot Plant for, 17: 32537 (HW-SA-2904)
oxidation-reduction states and potentials in solutions, 17: 32139
polarography in aqueous solutions, 17: 32139
puncture wound contaminated with, treatment and decontamination, 17: 31962 (DPSPU-63-30-5)
separation by solvent extraction, literature survey on, 17: 32190 (DP-700)
standard for, use of dicesium plutonium hexachloride as, 17: 31991

**PLUTONIUM ALLOYS**
Al–Pu, burnup in PRTR, 17: 32666 (HW-77935)

**PLUTONIUM ISOTOPES**
alpha activity of sources of, comparison of techniques of determining, 17: 32992 (AWRE-O-59/63)
neutron fission of, average number of fission neutrons in, 17: 33016

**PLUTONIUM ISOTOPES Pu-238**
fission of, alpha spectra from spontaneous, 17: 33079

**PLUTONIUM ISOTOPES Pu-239**
determination in environmental samples, radiochemical, 17: 32282 (AECL-1745)
effects of alpha particles from injected, on molecular weight of desoxyribonucleic acid in rabbits, 17: 31923
fission of, alpha spectra from spontaneous, 17: 33079
fission threshold of, determination by deuteron and gamma fission, 17: 33082
neutron cross sections for, energy-differential, 17: 32994 (CONF-39-37)
neutron fission of, characteristics of ternary, 17: 33019
neutron reactions (n,γ), cross section for thermal, 17: 32723(R) (PR-P-57(p.5-20))
pathological effects of injected, in bone, 17: 31926

**PLUTONIUM ISOTOPES Pu-240**
neutron fission of, alpha spectra from thermal, 17: 33079

**PLUTONIUM(IV) OXIDES**
decomposition of, effects of sintering on, 17: 32080
$Eu_2O_3$–$PuO_2$, phase studies, 17: 32572 (NP-13003)
$PuO_2$–$UO_2$, radiation effects on stainless-steel-clad, 17: 32663 (GEAP-3833)
$PuO_2$–$UO_2$, segregation effects in sintered pellets of, 17: 32604
$PuO_2$–$UO_2$, sintering behavior and stability of, in argon, carbon dioxide, and hydrogen, 17: 32634

**PLUTONIUM RECYCLE TEST REACTOR**
cooling system pumps for, development and testing of, 17: 33370 (HW-SA-3098)
flow monitors for, reduction of oscillations in, 17: 33368 (HW-70711 (Rev.))
fuel element burnup experiments in, 17: 32666 (HW-77935)
fuel element rupture in, fission product release from, 17: 33369 (HW-75045)

**PLUTONIUM SULFATES**
purification of tetrahydrate of, by ion exchange or successive recrystallization, 17: 32055

**PNEUMATIC SYSTEMS**
development of radiation-resistant, for space vehicles, 17: 32208(R) (GDC-63-140)

**POCKET CHAMBERS**
design with magnetically actuated charging means, 17: 32461(P)

**POLONIUM ISOTOPES Po-207**
decay of first excited state of, hindered E2 ground-state transition in, 17: 33039

**POLYMERS**
aging of, review on factors affecting, 17: 32677
bibliography on composites, 17: 32482 (AD-408618)
decontamination of, using ultrasonics, 17: 32304
dielectric loss in polymerization, research on, 17: 31796(R) (BNL-782 (p.44-50))
radiation chemistry of, review of, 17: 32176
radiation effects on aging and stability of high, review on, 17: 32677
radiation effects on, promotion by heavy metals, 17: 32700(P)

**POLYPHENYL ETHERS**
radiation effects on, cosmic, 17: 32693

**POLYPHENYL SYSTEMS**
biphenyl–terphenyl, separation of phosphorus-32 and sulfur-35 from reactor coolants of, 17: 33280

**POLYPHENYLS**
physical properties and stability as reactor coolants, 17: 32254
radiation and thermal stability, 17: 32156
radiation effects on, cosmic, 17: 32693

**POPULATIONS**
correlation of environmental background radiation and distribution of, 17: 31829

**POSITRONS**
detection and measurement, spectrometer for, 17: 32424
interactions with electrons, meson ($\pi$) pair production in, 17: 32958

**POTASSIUM**
determination by potentiometric titration using tetraphenyl borate, 17: 31998
determination in rocks and soils by radioactivity measurements, 17: 32264 (UCRL-10636)
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
dietary levels of, effects on retention of cesium-137, 17: 31836
electronic structure, 17: 32659
performance of pure vapors of, in magnetohydrodynamic cells, 17: 32817

**POTASSIUM ALLOYS**
Cs–K, thermoelectricity from electron and phonon scattering on, 17: 32785
K–Rb, thermoelectricity from electron and phonon scattering on, 17: 32785

**POTASSIUM BROMIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084

**POTASSIUM BROMIDES**
LiCl–KBr, phase studies, 17: 32113

**POTASSIUM CHLORIDE CRYSTALS**

cohesive energy of, Born analysis for, 17: 32084
**POTASSIUM CHLORIDES**
analysis for micro amounts of calcium, activation, 17: 31990
**POTASSIUM COMPLEXES**
Srilard-Chalmers effect in, 17: 32168
**POTASSIUM FLUONIOBATES**
spectra of niobium(V) ions in, infrared and Raman, 17: 32070
**POTASSIUM FLUORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**POTASSIUM FLUORIDES**
KF–NaF, reactions with cerium, neodymium and samarium oxides at 900 to 1100°C, 17: 32111
KF–$Na_4P_2O_7$, phase studies, 17: 32114
**POTASSIUM HYDROXIDES**
oxidation of zirconium, anodic current strength in, 17: 32528
**POTASSIUM IODIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**POTASSIUM NITRATES**
electrode processes in, 17: 31797(R) (BNL-782(p.51-9))
**POTASSIUM TANTALATES**
chemical properties in alkaline solutions, 17: 32123
**POTASSIUM THIOSULFATES**
radiation effects on electron spin resonance spectra of, 17: 32746
**POTATOES**
radiation and chemical effects on viability and aberrations in seeds of, 17: 31938
radiation effects on, 17: 32322
radiation effects on enzyme activity in, 17: 31945
radiosterilization of, effect on storage life, 17: 31945
**POWDERS**
sintering in crystalline, mechanisms of, 17: 32542(T) (UCRL-Trans-953(L))
**POWER PLANTS**
hydroelectric, cost trends for generation and transmission, 17: 32216
**POWER REACTORS**
design description of Swedish heavy-water, 17: 33350
design of 750-Mw(e) ORNL, GCR-3, 17: 33305 (CONF-39-49)
development of gas-cooled, objectives and plans for civilian, 17: 33304 (CONF-39-33)
development of gas-cooled, 17: 33316(R) (ORNL-3445)
development of large, prospects for, 17: 33344
development of SENN, for increased power output, quarterly summary No. 3, 17: 33311(R) (GEAP-4306)
development technology review, June 1963, 17: 33361
fluid flow and heat transfer parameters for pebble-bed, 17: 33325(R) (ORNL-3445(p.251-97))
fluid flow and heat transfer in pebble-bed, 17: 33326(R) (ORNL-3445 (p.298-328))
fuel cycle costs for pebble-bed, 17: 33325(R) (ORNL-3445(p.251-97))
fuel element manufacture for, quality control program to reduce costs of, 17: 33358
fuel management procedures for AVR, 17: 33325(R) (ORNL-3445 (p.251-97))
fuel processing facilities for, description of integrated, 17: 32203
information program on design and operating experience of, IAEA, 17: 33340
reactivity effects in thermal, from variations in nuclear parameters, 17: 33307 (EUR-281.e)
**POWER SUPPLIES**
description of nuclear, for space power uses, 17: 33391
design for electrostatic analyzers, 17: 32370
**PRASEODYMIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
effects on solubility of hydrogen in iron, 17: 32597
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
separation from neodymium by ion exchange, 17: 32202
spectra of, infrared, 17: 32739
**PRASEODYMIUM ALLOYS**
Bi–Pr, vaporization of, mass spectrometric study of, 17: 32033 (CONF-20-5)
Sb–Pr, vaporization of, mass spectrometric study of, 17: 32033 (CONF-20-5)
**PRASEODYMIUM CHLORIDES**
electric field parameters from orbital electrons of praseodymium trivalent ions in crystalline, 17: 32090
vapor pressure, 17: 32118
Pr–$PrCl_3$, phase diagram, 17: 32074
**PRASEODYMIUM CHROMATES**
preparation and structure, 17: 32103
**PRASEODYMIUM IONS**
electric field parameters from orbital electrons of trivalent, in trichloride crystals, 17: 32090
separation of, parameters for cation-exchange, 17: 32092
**PRASEODYMIUM ISOTOPES Pr-141**
lithium reactions ($Li^6$,5n) and ($Li^7$,6n) at 50.6–71.8 Mev, samarium-142 recoil range in, 17: 33094
proton reactions (p,n) on, cross sections for, 17: 33072
**PRASEODYMIUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**PRASEODYMIUM OXIDES**
stoichiometry of, 17: 32071
**PRASEODYMIUM PHOSPHIDES**
vaporization of, mass spectrometric study of, 17: 32033 (CONF-20-5)
**PRASEODYMIUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**PRASEODYMIUM SULFIDES**
crystal structure, 17: 32125
properties of, electric and magnetic, 17: 32081
**PRASEODYMIUM SYSTEMS**
As–Pr, vaporization of, mass spectrometric study of, 17: 32033 (CONF-20-5)
Pr–$PrCl_3$, phase diagram, 17: 32074
**PRECIPITATION**
tritium activity in, in Germany, 17: 32281
**PRESSURE REGULATORS**
development for use in radiation-resistant pneumatic power systems for space vehicles, 17: 32208(R) (GDC-63-140)
**PRESSURE VESSELS**
design and feasibility of prestressed-concrete, 17: 33235 (AAEC/TM-198)
design philosophy of prestressed concrete, review, 17: 33254
fabrication requirements, 17: 33361
stress analysis of, models for, 17: 33252
stress distributions around nozzle attachments to, 17: 33325(R) (ORNL-3445(p.251-97))
**PRESSURIZED WATER REACTORS**
coolant circuit breach detector and isolator, 17: 33292(P)
fuel cladding bursting in loss-of-coolant accident, 17: 32620
shielding design, 17: 33281
**PRODUCTION REACTORS**
uranium–plutonium cycle in water-moderated, 17: 33364
**PROMETHIUM CHLORIDES**
vapor pressure, 17: 32118
**PROPANE**
radiation effects on vapor phase nitration of, temperature dependence of gamma, 17: 32175
**PROPANE, 2-CHLORO-2-METHYL-**
hydrolysis of, in heavy and light water, effects of dioxane on solvent effect in, 17: 32063
**1-PROPANESULFONIC ACID, 2,3-DIMERCAPTO-**
protective effects against radiation damage to kidneys in dogs, 17: 31968
**1-PROPANOL**
solvent properties for elements, 17: 32194(R) (TID-19068)
**2-PROPANOL**
solvent properties for elements, 17: 32194(R) (TID-19068)
**1-PROPANOL, 2-METHYL-**
solvent properties for elements, 17: 32194(R) (TID-19068)
**PROPENEDIOL**
radioinduced polymerization of unsaturated esters of, with styrene, 17: 32177

**PROPIONAMIDE**
radiation polymerization of solid solution with acrylamide, 17: 31796(R) (BNL-782(p.44-50))
**PROPIONIC ACID, 2,2-DIMETHYL-**
synthesis and ionization constant of methyl-deuterated, 17: 32151
**PROPORTIONAL DETECTORS**
design and characteristics of very large boron trifluoride, for cosmic rays, 17: 32447
design of boron trifluoride-paraffin, for uniform angular response to fast neutrons, 17: 32432
development of methane-flow, 17: 32019
sensitivity of polyethylene–boron trifluoride, 17: 32445
use in probe for moisture determinations in loose materials, 17: 32018
**PROPULSION**
development of upper-stage systems for, comparison of chemical, electrical, and nuclear, 17: 33384
electric, design safety problems of nuclear reactors in space for, 17: 33388
electric, for control of stationary satellites, 17: 32220
electric, Mars and Venus mission parameters for, 17: 32222
electric, mission capabilities of, 17: 32223
electric, mission parameters for Jupiter orbit, 17: 32221
electric, potential of, 17: 32210
electrostatic systems for space, using cerium-144, 17: 33390
ion, material requirements for, 17: 32498
ion sources for, development of controlled-growth colloidal, 17: 32217
magnetohydrodynamic systems for space, using superconducting magnets, 17: 32224
nuclear electrogenerator systems for space, 17: 33391
nuclear systems for space, 17: 33386
plasma guns for space, design problems in, 17: 32225
plasma jet, satellite raising and orbit transfer parameters for, 17: 32219
systems for space, survey of, 17: 33387
systems of low-thrust, eccentricity and inclination changes effected by, 17: 32218
**PROTACTINIUM ISOTOPES**
neutron fission of, average number of fission neutrons in, 17: 33016
**PROTECTIVE CLOTHING**
dust removal from, design of chamber for, 17: 32318(P)
monitoring system for laundries, 17: 32286 (HW-76351)
of beryllium workers, handling and laundering, 17: 32291 (UCRL-7311)
**PROTEINS**
radiation effects on, ultraviolet thermoluminescence and electron paramagnetic resonance of, 17: 31850 (AD-294395)
radiation effects on blood serum content of, 17: 31907
radiation effects from injected phosphorus-32 on, in rats, 17: 31925
radiation effects on metabolism of, in lymph system, tracer study of, 17: 31932
**PROTON BEAMS**
activation of positron-emitting isotopes in mice bombarded with high-energy, 17: 31851 (BNL-6989)
biological monitoring of high-energy, 17: 31851 (BNL-6989)
extraction from bevatron, system for, 17: 33122 (UCRL-10868)
**PROTON SOURCES**
description of polarized, 17: 33130
**PROTON SPECTRA**
recoil, Monte Carlo interpretation of, 17: 32420
**PROTON SPECTROMETERS**
description of scintillation-telescope, 17: 32440
**PROTONS**
activation of carbon, nitrogen, and oxygen *in vitro* by, 17: 31851 (BNL-6989)
density and energy distribution in DCX-2, 17: 33152(R) (ORNL-3472 (p.9-23))
effects on bone marrow cells in mice, 17: 31942
eigenfunctions and energy levels of, in nonhomogeneous nuclei, 17: 33010
electron capture by fast, in hydrogen, 17: 33061
emission in deuteron reactions (d,p), angular distributions and polarization for, 17: 33036
emission in deuteron reactions (d,p) with nuclei, Coulomb interaction effects on angular distribution of, 17: 33067
emission in electron reactions (e,ep) with carbon-12 p and s shells, angular correlation for, 17: 33037
gamma elastic scattering by, cross section for, 17: 32912 (TID-7668 (Sect.IV))
interactions with mesons ($K^-$) at 2.7 to 5.2 Bev/c, total cross section for, 17: 32897 (BNL-6962)
interactions with mesons ($K^-$) at 2.3 Bev/c, resonance production in ($\Xi$-K-$\pi$) final-state, 17: 32898 (BNL-7105)
interactions with electrons at 950 Mev, proton polarization in, 17: 32905 (LAL-1072)
interactions with mesons ($\pi^-$) at 2 Bev/c, angular distributions for, 17: 32906 (NP-12990)
interactions with protons, Regge behavior of, 17: 32911 (TID-7668(Sect. III))
interactions with mesons (K), fermion Regge poles for asymptotics of, 17: 32933
interactions with photons, production of mesons ($\pi^+$) in, 17: 32964
interactions with emulsion nucleons at 28 Bev, effective target mass distribution for, 17: 32965
interactions with deuterons, gamma distribution and yield from, 17: 33003 (NEVIS-117)
ionization of gases by, cross sections for, 17: 32790
polarization in polystyrene, dynamic, 17: 32779
reactions on bromine and silver, lithium-8 from fission, 17: 33081
reactions on germanium isotopes, arsenic isotopes from, 17: 33075
reactions (p,$\alpha$) with aluminum-27 at 1.0–2.5 Mev, excitation functions for, 17: 33045
reactions (p,$\alpha$) on nuclei at 20.5 Mev, cross sections for, 17: 33070
reactions (p,$\gamma$) with aluminum-27 and nickel-58, resonance yield curves for, 17: 32998 (CONF-52-3)
reactions (p,$\gamma$) with carbon-12 at 10–48.5 Mev, excitation functions for nitrogen-13 ground and 3.5-Mev state from, 17: 33044
reactions (p,n) on nuclei, cross sections for, 17: 33072
reactions (p,n) with beryllium-9 at 3.7 to 8.5 Mev, polarization of neutrons from, 17: 33053
reactions with hydrogen atoms and molecules, charge exchange in, 17: 32837
reactions with nuclear emulsion at high energy, deuteron, helium-3 and triton production in, 17: 33091
scattering by argon-40 and fluorine-19, distributions from, 17: 33063
scattering by nuclei, two-electron exchange cross sections in, 17: 33077
scattering in nuclear emulsions at 6.2 Bev, 17: 32907 (NYO-10271)
scattering on carbon-12 at threshold to 48.5 Mev, excitation functions for 12.71 and 15.11-Mev states from, 17: 33043
scattering on even-even nuclei $16 \leq A \leq 40$, spin assignments for energy levels excited in inelastic, 17: 33012
scattering on nuclei, angular distributions and polarization for elastic and inelastic, 17: 33036
trapping in magnetic mirror machines by hydrogen dissociation, 17: 33151(R) (ORNL-3472(p.1-8))
**PSEUDOUREA, 2-(2-AMINOETHYL)-2-THIO-**
distribution in tissues in rats, tracer study of, 17: 31943
effects on enzymatic activity of irradiated pepsin, 17: 31940
effects on oxygen balance in man, 17: 31833
protective effects against radiation damage to bone marrow in mice, 17: 31942
protective effects against radiation injuries in cells in tissue culture, 17: 31944
protective effects against radiation damage in mice, correlation of dose with, 17: 31966
**PSEUDOUREA, 2-ETHYL-2-THIO-**
protective effects of, against radiation damage to mice, effects of papaverine on, 17: 31948
**PSYCHOLOGY**
dominance-submission patterns in female dogs, effects of irradiation and age, 17: 31864(R) (UCD-107(p.86-97))
field research program, for dogs, 17: 31863(R) (UCD-107(p.74-85))
**PULSE ANALYZERS**
channel width of single-channel, optimum, 17: 32429
description of nsec-range pulse-height discriminator, 17: 32436
description of shape discriminator for eliminating superposed pulses in

nuclear spectroscopy, 17: 32441
description of, using amplitude-to-digital conversion, 17: 32437
design of transistorized time-amplitude converter for positron lifetime measurements, 17: 32358
developments at Chalk River, 17: 32726(R) (PR-P-57(p.44-68))
**PULSE GENERATORS (ELECTRONICS)**
design for current pulse synthesis, 17: 32394(P)
device for generating pseudo-random gating impulses, 17: 32344(T) (AEC-tr-5901)
**PULSES**
average amplitude of spectra, electronic device for measurement of, 17: 32354
spectrum expansion for kicksorter, bias unit for, 17: 32355
**PUMPS**
development and testing of, for PRTR cooling system, 17: 33370 (HW-SA-3098)
performance of mechanical seals for shafts of primary-coolant, 17: 32215
**PUREX PROCESS**
waste solution processing for cesium removal, 17: 33396 (HW-SA-2920)
**PYRIDINE**
effects of tritiated water on, in presence of ammonium chloride, 17: 32142

# Q

**QUALITY CONTROL**
program for economic manufacture of power reactor fuels, 17: 33358
**QUANTUM ELECTRODYNAMICS**
photon Green's function in, effects of virtual $\pi$ mesons on, 17: 32955
relativistic theory of the spin electron in Riemannian space, 17: 32963
theory of, development and testing of, 17: 32909 (TID-7668(Sect.I))
theory of, tests of, 17: 32916 (TID-7668(Sect.VIII))
**QUANTUM MECHANICS**
calculation of ground-state properties of many-particle systems using reduced density matrices, 17: 33227 (NYO-10431)
characteristics of Lee-Yang charged-vector-meson field theory, 17: 32959
conservation laws in relativistic, derivation of covariant, 17: 32805
description of high-energy interactions in, 17: 32952
dispersion relations in, integration of, 17: 33229
eigenvalues of a matrix, methods for computing, 17: 33226 (NYO-10429)
elementary particle model in, with nonzero angular momentum, 17: 32961
elementary particle weak interactions in unitary-symmetric, 17: 33233
energy levels in a square well with hard core, 17: 33001 (CONF-128-1)
equivalence between two generalized master equations in, 17: 33232
evolution to statistical equilibrium for a simple model, 17: 33231
field theory axioms in, properties of relativistic, 17: 32760
formulation of local quantum field theory, without u-v divergences, 17: 32807
many-particle system, angular-internal motion separation in, 17: 33228
operators in, invariant parameterization of local, 17: 32953
particle motion in one-dimensional square-well potential, propagator for, 17: 32938
scattering by potential wells in, Regge-pole effects on, 17: 32956
scattering phase-shift ambiguities in, 17: 33234
superfluid rotatory flows in, stability of, 17: 32808
symmetry groups in, 17: 32800
theory of continuous representation in, postulates for Hilbert space, 17: 32762
theory of continuous representation in, generalized relation with classical dynamics, 17: 32763
transitions in, theory of two-quantum, 17: 32765
use of diatomic orbitals in calculations of the electronic wave functions of diatomic molecules, 17: 32721 (NYO-10423)
validity of, testing by analyses of two-step processes, 17: 33069
variation principles for an arbitrary operator, off-diagonal elements and scattering states in, 17: 33230
wave equations in, expansions for Dirac radial relativistic, 17: 32479
wave equations in, cross-correlation function for field amplitude, 17: 32761
wave functions for the hydrogen molecule and molecule ion based on 1s-type orbitals, 17: 32767
wave functions for atoms with Z = 1 to 10, 17: 32796
**QUARTZ**
radioinduced polymer film formation on, 17: 32695

# R

**RABBITS**
radiation effects on hematopoietic system in, effects of phenylhydrazine on, 17: 31974
radiation effects on cytochromoxidase and succinic dehydrogenase activity in liver, nervous system, and skeleton in fractionated, 17: 31979
radiation sickness in, effects of glycocoll and peptone on ammonia and nitrogen content in blood during, 17: 31975
radiation sickness in, therapeutic effects of sodium chlorophyllin on, 17: 31976
**RADIATION**
biological effects on *Lemna minor*, use as radiobiological test for clinical radiotherapy, 17: 31873
catalytic effects of, in presence of nonmetallic solids, 17: 32178
chimeras, lysozyme activity in kidneys of mouse, 17: 31919
directional correlation measurements, variances in, 17: 33031
dosage to man from television sets and luminous dials, 17: 32309
dosimetry in radiodiagnosis and radiotherapy, 17: 31826
effects on blood vessels, physiological, 17: 31874
effects on cells, 17: 31881
effects on constituents of blood plasma, chemical, 17: 31875
effects on dogs, effects of allogenous bone marrow transplantation on, 17: 31969
effects on enzyme activity in potato tubers, 17: 31945
effects on intensity of second fluorescence of lymphocytes in mice, 17: 31952
effects on kidneys in dogs, protective effects of unithiol against, 17: 31968
effects on nervous system functions, 17: 31908
effects on physiology and reproduction in domestic animals, 17: 31816(R) (ORO-605)
equipment and procedures for measuring environmental, 17: 32312
genetic effects on plants, environmental factors in, 17: 31951
measurement of environmental, 17: 32290(R) (TID-19111)
pneumonitis caused by, review of, 17: 31965
survey of environmental background in Germany and Switzerland, 17: 31829
**RADIATION CHEMISTRY**
of electrode reactions, mechanism of rate change in, 17: 32171
of hydrocarbons, review of, 17: 32170
of polymers, review of, 17: 32176
**RADIATION DETECTION INSTRUMENTS**
book: *Experimental Nucleonics*, 17: 32455
book: *Measuring Techniques for Radioactive Preparations*, 17: 32456
design of gamma attenuation, for detection of vapor volume fraction, 17: 32241(R) (ACNP-63020)
design of monovibrator, for bremsstrahlung energy measurement, 17: 32401 (LNF-63/17)
development and characteristics of whole-body counters as, 17: 32301
development and evaluation of, for measurement of environmental radiation, 17: 32290(R) (TID-19111)
development, for monitoring protective clothing after laundering, 17: 32286 (HW-76351)
development of equipment and techniques for radiocardiography studies, 17: 31818 (TID-19168)
development of equipment and techniques for radiocardiography studies, 17: 31819(R) (TID-19173)
developments, 17: 32724(R) (PR-P-57(p.21-36))
recoil proton spectra from neutrons incident on recoil, Monte Carlo interpretation of, 17: 32420
**RADIATION DETECTION INSTRUMENTS (PULSE TYPE)**
design for aerial geophysical prospecting, 17: 32462(P)
design for measuring peak intensity and total energy of pulses, 17: 32463(P)
design for measuring intensity of radiation consisting of components of very different intensities, 17: 32465(P)
design for measuring natural levels of thorium-228, 17: 31984 (CONF-

16-1)
design of low-level beta counter for training, engineering drawings for, 17: 32374
method for obtaining comparable photographs of an oscilloscope display in analysis by the gray-wedge technique in, 17: 32464(P)
operation of analog-to-digital converter, errors and precisions in, 17: 32408

**RADIATION DETECTORS**
description of, for alpha-gamma angular correlation studies, 17: 32446
design of readers for thermoluminescent, 17: 32448
development and uses of thermoluminescent materials as, for x-ray dosimetry, 17: 32402(R) (TID-19112)

**RADIATION EFFECTS**
determination of "pure," on mammals, 17: 31883
in ionic crystals, production of anion defects or color centers in, 17: 32671 (ZFK-WF-22)
in space, NASA laboratory for studies of, 17: 32699
on corrosion, mechanical, physical, and thermal properties of alloys and metals, 17: 32679
on metal creep in fast neutron field, measurement of, 17: 32697
on metals and organic materials, review of, 17: 32683
on plastic deformation of metals and steel alloys, 17: 32684
on polymers, promotion by heavy metals, 17: 32700(P)
on rate change of electrode reactions, mechanism of, 17: 32171
research program of Air Force Materials Laboratory, 17: 32513
theory of, in solids, 17: 32674

**RADIATION INJURIES**
bone marrow destruction in gamma-irradiated rats, 17: 31931
chemical prophylaxis against, in organisms, 17: 31956
effects of synestrol on, in mice, 17: 31941
effects on life span in dogs, delayed, 17: 31868(R) (UCD-107(p.275-81))
in cells in tissue culture, protective effects of aminoethylisothiuronium and propyl gallate on, 17: 31944
induction by nuclear explosions, management and treatment of, 17: 32295(T) (JPRS-20511)
of gastrointestinal tract, protective effects of cortisone, ACTH, insulin, atrophine, and chloropromazine on, 17: 31896
pathology of, effects of tissue content of copper, cobalt, and iron on, 17: 31928
protection against, during radiology using a carotid compression device, 17: 32306
to blood-forming elements of dogs, 17: 31930

**RADIATION PROTECTION**
afterloading of therapeutic radiation sources, 17: 31878
regulations for, in x-ray testing of steel tube welding seams, 17: 32307
regulations for, relation of safety to, 17: 32317
testing radium capsules for leakage, 17: 31879

**RADIATION SICKNESS**
effects of, on hematopoietic system in rabbits, effects of phenylhydrazine on, 17: 31974
effects on content of natural and injected gamma globulin in rabbits, 17: 31972
effects on immunity, epidemiology of, 17: 31977
in rabbits, effects of glycocoll and peptone on ammonia and nitrogen content in blood during, 17: 31975
in woman, case history of ophthalmological changes in acute, 17: 31978
mechanism of blood formation disturbances in, 17: 31941
protective effects of bone marrow transfusions against, nature of, 17: 31970
protective effects of bone marrow transplantation against acute, in rats, 17: 31971
therapeutic effects of sodium chlorophyllin on, in rabbits, 17: 31976
therapy of, using sodium lactate, negative results, 17: 31964(T) (JPRS-20469)
therapy with homogenates of liver, spleen, or thymus, 17: 31973
treatment with cold-preserved bone marrow, 17: 31963(T) (JPRS-20282(p.17-26))

**RADIATION SOURCES**
afterloading of therapeutic, 17: 31878
energy absorption in, photon, 17: 31796(R) (BNL-782(p.44-50))
leak test for radium, 17: 31880
preparation of thin foils by cathode sputtering, 17: 32769
preparation of thin foils by cathode sputtering, 17: 32770
testing radium capsules for leakage, 17: 31879

**RADIATION TARGET CANS**
welding of aluminum capsules for hermetic sealing, device for, 17: 32549

**RADIATORS**
materials selection for, in space power plants, 17: 33393

**RADIO WAVES**
attenuation of whistler, thermal, 17: 33143 (D1-82-0229)
emission by plasma, 17: 33153(R) (ORNL-3472(p.24-49))
emission by sun, description of type IV, 17: 32877
emission from solar corona, frequency drift of type III, 17: 32855
generation of vlf, by geomagnetically trapped particles, 17: 32868
interactions with plasma, electric wave production by, 17: 33186
propagation through cylindrical plasma sheaths, 17: 33202
sources of galactic, identification with stellar objects, 17: 32847
spectra of whistlers from nuclear explosions, 17: 32757

**RADIOACTIVE MATERIALS**
handling of, reduction of shipper-receiver differences in, 17: 32315
regulatory control in Kentucky, state program for, 17: 32316

**RADIOACTIVE VOLTAGE GENERATORS**
performance for space propulsion using cerium-144, 17: 33390

**RADIOACTIVITY**
book: *Measuring Techniques for Radioactive Preparations*, 17: 32456
content in atmosphere of natural, 17: 32280
distributions and effects of ambient, survey, 17: 32276

**RADIOAPPLICATORS**
therapy of hemangioma using phosphorus-32, effects on peripheral blood, 17: 31905

**RADIOAUTOGRAPHY**
technique for study of tracer incorporation in different ways at same time, 17: 31834
use of tritium-labeled amino acids in, 17: 31842
use of xerographic processes in, 17: 32352
used to study incorporation of tritiated amino acids into mouse cell nuclei, 17: 31887

**RADIOCHEMICAL PROCESSING PLANTS**
description of fuel-processing, integrated with reactor stations, 17: 32203

**RADIOCHEMISTRY**
bibliography on research on, at Hungarian Academy of Sciences, 17: 31810
separation of short-lived nuclides by beta recoil, 17: 32173
separations in, use of distillation techniques in, 17: 32154 (NAS-NS-3108)

**RADIODIAGNOSIS**
use of gold-198 in, bibliography on, 17: 31814 (KFK-143)

**RADIOFREQUENCY GENERATORS**
design of 73.6-Mc, for AdA storage rings, 17: 33116 (LNF-63/10)

**RADIOFREQUENCY SPECTROMETERS**
magnetic field inhomogeneity compensation in, 17: 32367
measurement in very weak magnetic fields, 17: 32390
signal-to-noise enhancement by continuous averaging, 17: 32363

**RADIOGRAPHY**
dose measurements in vicinity of dental x-ray unit, 17: 32308

**RADIOISOTOPES**
bibliography on research on biological applications of, 17: 31810
detection and measurements of, techniques for, 17: 32456
determination in dusts, sampling techniques for, 17: 32310
determination in waste solutions, development of methane flow counter for, 17: 32019
determination of, variable coincidence counter for, 17: 32409
fixation in ceramic microspheres, 17: 32327
gamma emission of thermal-neutron activated, energy tabulation, 17: 32709 (IFA/SN/17)
half lives of, tables of, 17: 32709 (IFA/SN/17)
laboratory, design of coordinated, 17: 31805
measurement of, in man, review of development of, 17: 32301
preparation, properties, and uses of, 17: 32174
radioactivity from, distributions of, 17: 32276
separation of short-lived, by beta recoil, 17: 32173
sorption by sedimentary particles in the sea, 17: 31830 (TID-19127)
storage, in laboratory, 17: 32296

use in automation, 17: 32331
use in coal production, 17: 32320 (CONF-124-2)
use in paleontological studies, 17: 31826
use in surgery, 17: 31828
**RADIOLOGICAL DEFENSE**
training course for personnel, 17: 31855(R) (TID-19126)
**RADIOLOGY**
radiation protection during, using a carotid compression device, 17: 32306
**RADIOMETERS**
design and performance of gated microwave, for electron temperatures in plasma afterglow, 17: 33217
**RADIOMETRIC ANALYSIS**
equipment for, for determination of thorium-228 at natural levels, 17: 31984 (CONF-16-1)
of carbon–hydrogen ratio in hydrocarbons, engineering drawings of equipment for, 17: 32382
of environmental samples, manual on, 17: 32282 (AECL-1745)
**RADIOSENSITIVITY**
effects of chemical protective substances on, 17: 31940
of brain, effects of protective membrane on, 17: 31934
of microspores of *Tradescantia paludosa* in mitosis, changes in, 17: 31937
of oocytes at different maturation stages in rats, 17: 31913
of plants, relation of chromosome number and nuclear volume to, 17: 31949
of Salmonella bacteria species in eggs, 17: 31889
**RADIOSTERILIZATION**
commercial potato, in Canada, 17: 32322
effective minimum dose required to control insects, 17: 32323
of eggs against Salmonella bacteria, 17: 31889
of glass ampules containing medicine, 17: 32675
of potatoes, effects on storage life, 17: 31945
research on food, in Germany, 17: 32324
**RADIOTHERAPY**
afterloading of radiation sources, 17: 31878
clinology and methodology, 17: 31826
leukopenia development from gamma, characteristics of, 17: 31904
measurement of absorbed x-ray and by calorimetry for, 17: 32305
of carcinoma of uterine cervix, effects on leukocyte count of peripheral blood, 17: 31906
of malignant growths, effects on content of blood proteins and riboflavin during, 17: 31907
of tumors of head and neck region, radiation hazards, 17: 31872
radiobiologic test for use with clinical radiation doses, 17: 31873
skin reactions, reduction of, 17: 31871
testing radium capsules for leakage, 17: 31879
use of cobalt-60 in, techniques and devices for, 17: 31823
use of electron beams in, problems in, 17: 31824
use of gold-198 in, bibliography on, 17: 31814 (KFK-143)
use of radioisotopes for, in surgery, 17: 31828
with high-energy electrons, pencil beam scanning, 17: 31870
**RADIUM**
determination in urine and water by sorbe-mulsion method, 17: 32013
environmental exposure to, in drinking water, 17: 32314
leak test for sealed sources, 17: 31880
**RADIUM ISOTOPES Ra-226**
content in Maine and New Hampshire ground waters, 17: 32312
determination of traces in teeth, scintillation, 17: 32459
uptake in persons from water, 17: 32314
**RADON**
determination in air, engineering drawings of equipment for, 17: 32375
determination of very low levels of, scintillation detector for, 17: 32459
**RADON FLUORIDES**
preparation of, review of, 17: 32051(T) (AEC-tr-5920)
**RADON ISOTOPES Rn-222**
content in Maine and New Hampshire ground waters, 17: 32312
**RAIN WATER**
analysis for deuterium, 17: 32272
radiological monitoring in France, May 1963, 17: 32289(R) (SCPRI(RM)V-1963))
**RARE EARTH BORATES**
crystal structure and composition, 17: 32035 (CONF-20-28)
**RARE EARTH COMPOUNDS**
magnetic properties and nuclear hyperfine fields of types $ACo_5$ and $AFe_3$, 17: 32819
**RARE EARTH GLASSES**
electrochemical properties of lithium-containing, 17: 32094
**RARE EARTH HALIDES**
preparation of anhydrous single crystals of, 17: 32087
**RARE EARTH NIOBATES**
preparation and crystal structure, 17: 32100
**RARE EARTH SALTS**
magnetic relaxation in, 17: 32818
**RARE EARTH TANTALATES**
preparation and crystal structure, 17: 32100
**RARE EARTHS**
analysis of mixtures of, spectrophotometric, 17: 32002
determination in uranium, spectrophotometric, 17: 32027
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
properties of, chemical and physical, 17: 32648
separation by electrophoresis on paper in nitrilotriacetic acid, 17: 32196(T) (UCRL-Trans-973)
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)
separation of, review of methods for, 17: 32197
**RATE METERS**
development of solar cell dosimeter, 17: 31796(R) (BNL-782(p.44-50))
development of transistorized digital, 17: 32340 (TID-19170)
properties of copper-63 neutron dosimeters, 17: 33000 (CONF-67-15)
response of linear, effects of random fluctuations on, 17: 32434
**RATS**
calcium-45 and strontium-90 uptake by skeleton of, effects of stable strontium on, 17: 31831(T) (JPRS-19626)
radiation effects on metabolic processes in, effects of nutritional condition on, 17: 31838
radiation effects of localized exposure, 17: 31883
radiation effects on bone marrow cells in, gamma, 17: 31931
radiation effects on absorption of iodine-131-labeled sodium iodide by skin of, 17: 31957
radiation sickness in, protective effects of bone marrow transplants in, 17: 31971
uptake of tyrosine in growing hair of, radioautography of different ways of, 17: 31834
**REACTION MECHANISMS**
catalysis by irradiation in presence of solids, 17: 32178
**REACTOR COMPONENTS**
brazing, plating, ultrasonic testing, and welding of steel techniques for, 17: 33260
**REACTOR CONTROL ELEMENTS**
materials for, properties of neutron-absorbing, 17: 32493
**REACTOR CONTROL RODS**
calibration by rod-drop method, 17: 33374 (ORNL-TM-605)
development of gadolinium oxide, 17: 33236(R) (ACNP-63022)
**REACTOR CONTROL SYSTEMS**
design for suspension reactor, 17: 33295(P)
for nuclear rockets, review of, 17: 33389
**REACTOR COOLANTS**
heat-transfer properties of organic, 17: 32254
properties of gaseous, comparison of, 17: 33325(R) (ORNL-3445(p.251-97))
separation of phosphorus-32 and sulfur-35 from organic, by adsorption, 17: 33280
stability of organic, 17: 33361
**REACTOR COOLING SYSTEMS**
coolant flow restrictor design for vertical coolant channels, 17: 33291(P)
deposition of fission products in, 17: 33322(R) (ORNL-3445(p.138-98))
detection and isolation of a breached fluid-coolant pressure circuit, 17: 33292(P)
fission-product transport and deposition from gas streams in, 17: 33243 (ORNL-3379)
leaks around impeller shaft, prevention of, 17: 33290(P)
pumps for, performance of mechanical seals for shafts of, 17: 32215
sealed-joint design for fuel channel and header tank, 17: 32228(P)

valve design and testing for primary, 17: 32227

**REACTOR ENGINEERING**
book: *Introductory Nuclear Reactor Theory*, 17: 33266
coolant leak prevention system, 17: 33290(P)
core component design for minimum cost, 17: 33282
core design containing burnable poisons, 17: 33289(P)
core structure design with removable subassemblies, 17: 32236(P)
developments at Brookhaven, 17: 31799(R) (BNL-782(p.92-4))
fuel development in Canada, 17: 33258
handbook for operation of test reactors, 17: 33371 (IDO-16871-1)
liquid-moderator flow-control device, 17: 33293(P)
nuclear defense considerations in construction and siting of nuclear power plants, 17: 33361
reactivity effects due to variations in nuclear parameters in a thermal power reactor, 17: 33307 (EUR-281.e)
semianalytical and seminumerical calculations of optimum material distributions, 17: 33237 (AE-110)
theory of delayed supercritical excursions to measure Doppler coefficients of fast reactors, 17: 33242 (KFK-153)

**REACTOR FUEL ELEMENTS**
analysis for uranium-235, gamma spectrometric, 17: 32012
burnup testing of stainless steel-clad thoria–urania and urania, 17: 33323(R) (ORNL-3445(p.199-217))
clad bursting in loss-of-coolant accident, 17: 32620
cladding failure in superheat, effects of strain cycling on, 17: 33239 (GEAP-4244)
cladding of, with graphite, development of production scale procedure for, 17: 33279
design of container with removable subassemblies, 17: 32236(P)
design of finned spheroidal, 17: 33296(P)
design of sheaths containing burnable poisons for, 17: 33289(R)
design to flatten flux distribution in boiling moderator reactors, 17: 33283(P)
design to prevent vibration in vertical channels, 17: 33284(P)
design to prevent vibration in vertical channels, 17: 33285(P)
design to prevent vibration in vertical channels, 17: 33286(P)
development and testing of pyrolytic carbon-coated uranium carbide and stainless steel-clad urania, 17: 33322(R) (ORNL-3445(p.138-98))
development and testing of stainless steel-clad thoria-urania, 17: 33322(R) (ORNL-3445(p.138-98))
development in Canada, 17: 33258
development of beta-treated uranium for, 17: 32538(R) (NMI-2801)
development of beta-treated uranium for, 17: 32539(R) (NMI-2805)
dissolution of stainless steel- and zirconium alloy-clad, in nitric acid, electrolytic, 17: 32192(R) (DP-839)
fission gas release from impregnated graphite shells of, 17: 33273
fluid flow and heat transfer in 7-rod cluster, 17: 33326(R) (ORNL-3445 (p.298-328))
manufacture for power reactors, quality control program to reduce costs in, 17: 33358
oxidation rates of punctured Magnox-clad uranium, by carbon dioxide and air at 450 and 550°C, 17: 32527
performance, 17: 31798(R) (BNL-782(p.60-91))
processing of irradiated, halogenation methods for, 17: 32199
rachetting of metal-clad, during thermal cycling, 17: 33323(R) (ORNL-3445(p.199-217))
shipping casks for irradiated, new developments in design of, 17: 32303
temperature measurement in, electrically with no direct connections, 17: 32230(P)
wet processing of irradiated, industrial plants and procedures for, 17: 32201

**REACTOR FUEL ELEMENTS (CERAMIC)**
design for high burnups, 17: 33288(P)
fabrication and properties of cylindrical and tubular stainless steel–uranium dioxide, 17: 33276
fabrication of stainless steel-clad uranium dioxide, by high-temperature coextrusion, 17: 32536 (GEAP-4282)
fabrication, properties, and radiation effects on, review on, 17: 33270
production process for, 17: 33298(P)
radiation effects on plutonium dioxide–uranium dioxide, 17: 32663 (GEAP-3833)
thermal stability of graphite-matrix carbides, 17: 32570 (GA-2880)

**REACTOR FUEL ELEMENTS (DISPERSION)**
development and irradiation testing of graphite matrix with uranium carbide particles, 17: 33322(R) (ORNL-3445(p.138-98))
development and testing of beryllia matrix with urania particles, 17: 33322(R) (ORNL-3445(p.138-98))
fabrication, properties, and radiation stability of carbide and oxide, 17: 33262
reprocessing of uranium dioxide–graphite, fission product removal during nitric acid leach in, 17: 32200

**REACTOR FUEL PLATES**
design and fabrication of sheathed, 17: 33294(P)
fabrication incorporating a temperature-measuring device, 17: 33287(P)
fastener-spacer for, 17: 33301(P)

**REACTOR FUEL RODS**
handling in reactors, manipulator for, 17: 32238(P)
radiation effects on swaged-powder uranium dioxide, 17: 32664 (GEAP-4197)

**REACTOR FUEL SPHERES**
development and fabrication of graphite–uranium carbide, 17: 33321(R) (ORNL-3445(p.111-37))
development and irradiation testing of graphite–uranium carbide, 17: 33322(R) (ORNL-3445(p.138-98))
fission product diffusion in graphite–uranium carbide, 17: 33321(R) (ORNL-3445(p.111-37))

**REACTOR FUEL TUBES**
fabrication, 17: 32559(P)

**REACTOR FUELS**
burnup of plutonium-enriched, effects on reactivity, 17: 33240(R) (GEAP-4303)
development in Canada, 17: 33258
development of uranium nitrides as, 17: 32483(R) (BMI-X-10027)
development of uranium carbide-uranium dioxide, 17: 32486(R) (NCSC-2663-13)
fabrication and properties of uranium-uranium carbide, 17: 32487(R) (NCSC-2981-4)
fabrication of plutonium-containing, design of pilot plant for, 17: 32537 (HW-SA-2904)
management by reactor operators, 17: 33269
processing facilities for, integrated with reactor stations, 17: 32203
processing of, research on, 17: 31795(R) (BNL-782(p.18-43))

**REACTOR MATERIALS**
properties for use in radiators for heat rejection in space, 17: 33393
properties of neutron-absorbing, for reactor control, 17: 32493

**REACTOR MATRICES**
analysis of water-moderated uranium-fueled, 17: 31794(R) (BNL-782 (p.1-17))
burnup and reactivity calculations for rod-clustered pressure-tube, computer program for, 17: 33238 (CVNA-146(Vols.I&II))
fuel chambers for Canadian nuclear power, fabrication of stainless steel, 17: 33333
neutron spectra in multiplying, measurements of, 17: 32971 (CONF-11-9)
reactivity of plutonium–uranium, in water-moderated reactors, 17: 33364

**REACTOR MODERATORS**
design of block assembly, 17: 33300(P)
materials development for, 17: 33324(R) (ORNL-3445(p.218-50))
properties of predeuterated, 17: 31794(R) (BNL-782(p.1-17))
stacking of, review of techniques of, 17: 33250

**REACTOR OSCILLATORS**
design of global, for neutron physics measurements in Rossendorf Research Reactor, 17: 33380

**REACTOR REFLECTORS**
design, 17: 33299(P)

**REACTOR SAFETY**
coolant leak prevention system, 17: 33290(P)
device for detecting and isolating breach in fluid-coolant pressure circuit, 17: 33292(P)
fuel element clad bursting in loss of coolant accident, 17: 32620
of reactors to be operated in space, 17: 33388
review, 17: 33259
review of containment, radiation control and siting, 17: 33361

**REACTOR SHIELDING**
design for pressurized water reactors, 17: 33281

stress analysis of loading-face, in Hallam Power Reactor, 17: 33251
technology of concrete as, 17: 33378
**REACTOR SIMULATORS**
spatial representation methods, 17: 33268
**REACTORS**
book: *Introductory Nuclear Reactor Theory*, 17: 33266
burnup and decay in, computer program for correction to sensor activity for, 17: 33241 (HW-78131)
development at Brookhaven, 17: 31794(R) (BNL-782(p.1-17))
instrumentation for, development, 17: 32726(R) (PR-P-57(p.44-68))
kinetics of, transfer functions in spatial, 17: 33257
material distributions in, semianalytical and seminumerical calculations of optimum, 17: 33237 (AE-110)
neutron thermal activation rates in, reduction to continuous spectrum, 17: 33245 (WAPD-T-1582)
neutron thermalization in, velocity polynomial calculation of, 17: 32973 (CONF-39-46)
nuclide concentrations in, computer determination of, 17: 33244 (ORNL-TM-361(Add.))
physics, weighting functions in, 17: 33255
reactivity in, neutron source modulator for measurement of, 17: 32344(T) (AEC-tr-5901)
research programs on, ninth annual summary of UKAEA, 17: 31800(R) (NP-12981)
**REFRACTORY MATERIALS**
boiling points of, calculation of, 17: 32592
coating of, by plasma-arc spraying, 17: 32545
corrosion by mercury, 17: 31798(R) (BNL-782(p.60-91))
radiation effects on corrosion, mechanical, physical and thermal properties of, 17: 32679
wear properties at 70 to 1900°F, survey of, 17: 32208(R) (GDC-63-140)
welding in ionizer fabrication, electron-beam, 17: 32557
**RELATIVITY THEORY**
conservation laws in, derivation of covariant, 17: 32805
Dirac electron theory in general, formulation of, 17: 32735(T) (UCRL-Trans-981)
Dirac matrices in general, symmetrical form of, 17: 32736
operators in, invariant parameterization of local, 17: 32953
space conformal transformations in general, spinor formalism for, 17: 32787
**REMOTE-CONTROL EQUIPMENT**
design of manipulator with detachable head, 17: 32231(P)
design of manipulator with angularly adjustable handle, 17: 32233(P)
design of manipulator to operate over a wall, 17: 32234(P)
design of manipulator with jointed arm for greater access, 17: 32237(P)
design of manipulator for replacing fuel rods, 17: 32238(P)
design of top-of-wall mounting for manipulator, 17: 32232(P)
development of vacuum cathodic etcher, 17: 32213
**REMOTE-VIEWING EQUIPMENT**
design for shielded enclosures, 17: 32235(P)
**RENÉ-41**
corrosion, oxidation, and strength of, comparison of nickel–thorium oxide system with, 17: 32501
**RESEARCH REACTORS**
criticality studies of Advanced Pressure Tube Reactor, hazards evaluation for, 17: 33373 (NP-12998)
design of KEMA Suspension Test Reactor, 17: 33377
fluid flow measurements in compact core of German FRJ-1, 17: 33372 (JÜL-125-RE)
irradiation facilities in ISPRA-1, 17: 33365 (EUR-374.e)
neutron physics measurements in Rossendorf, global pile oscillator for, 17: 33380
nuclear and physical characteristics of SILOE, 17: 33376
operation at universities within the local, state, and federal regulations, 17: 33382
operation of testing, fundamentals of, 17: 33371 (IDO-16871-1)
shielding measurements for German WWR-S, 17: 33381
shielding of Israel, concrete as, 17: 33378
**RESINS**
diffusion of ions in Dowex 50W, rate of, 17: 32053
**RESPIRATORS**
for uranium ore processing plants, 17: 32311
**RETICULO-ENDOTHELIAL SYSTEM**
physiology, tracer studies, 17: 31852 (BNL-7137)
**RHENIUM**
cesium ionization on, efficiency of, 17: 32825
oxidation states of, chemistry of, 17: 32137
properties of, for use in thermocouples, mechanical and thermoelectric, 17: 32644
**RHENIUM ALLOYS**
Mo–Re, properties as superconducting magnet, 17: 32712 (LNF-63/26)
**RHENIUM ELECTRODES**
cesium film behavior on, 17: 32827
**RHENIUM ISOTOPES Re-185**
energy levels of, lifetime of first excited-state, 17: 33040
**RHENIUM ISOTOPES Re-186**
beta decay of, analysis of first-forbidden, 17: 33015
**RHENIUM ISOTOPES Re-187**
energy levels of, lifetime of first excited-state, 17: 33040
**RHENIUM ISOTOPES Re-188**
beta decay of, analysis of first-forbidden, 17: 33015
**RHODIUM**
properties of, for use in thermocouples, mechanical and thermoelectric, 17: 32644
**RHODIUM COMPLEXES**
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068
**RHODIUM ISOTOPES Rh-103**
neutron radiative capture in, optical model for cross sections of, 17: 33048
**RIBONUCLEIC ACID**
radiation effects on content of, in organs and tissues in chickens, 17: 31955
**RIBONUCLEIC ACID, DESOXY-**
differentiation of nuclei synthesizing, 17: 31887
effects of content of highly polymerized, in tissue homogenates on therapeutic effects in radiation sickness, 17: 31973
radiation effects on, studied by thermal strand separation method, 17: 31922
radiation effects on molecular weight of, from injected plutonium-239 in rabbits, 17: 31923
radiation effects on content of, in organs and tissues in chickens, 17: 31955
radioinduced denaturation, mechanism, 17: 31912
radioinduced destruction in *Escherichia freundii*, reaction mechanisms, 17: 31899
radiosensitivity of 5-bromouracil-substituted, uv, 17: 31885
radiosensitivity of 5-bromouracil-substituted, uv, 17: 31886
**RIBONUCLEIC ACID, DESOXY- COMPLEXES**
deoxynucleotide polymerase-, in *E. coli*, 17: 31832
**ROCKET MOTOR NOZZLES**
design and performance of, for controlled-growth colloidal ion source, 17: 32217
plasma expansion at, supersonic, 17: 32835
**ROCKET MOTORS**
ion, efficiency of cesium, 17: 32825
ion, fabrication of refractory metal ionizers for, 17: 32557
**ROCKET REACTORS**
control system and instrumentation for, review of, 17: 33389
design safety problems, 17: 33388
gas-core, fuel containment by MHD-driven vortices in, 17: 33394
performance of gas-core, potential of, 17: 33383
radiator for heat rejection in space, materials selection for, 17: 33393
survey, 17: 33386
**ROCKETS**
control and instrumentation problems in nuclear, 17: 33389
nuclear, development program for, 17: 33385
**ROCKS**
ages of Antarctic, review of, 17: 32266
analysis for hafnium and zirconium, neutron activation, 17: 31986 (TID-19179)
book: *Radiogenic Argon in Minerals and Rocks*, 17: 32278
radioactivity of, measurements of gamma, 17: 32264 (UCRL-10636)
**ROTARY SEALS**

performance of mechanical, for shafts of primary coolant pumps, 17: 32215
**RUANDA-URUNDI**
ages of pegmatite and vein minerals from, 17: 32268
**RUBBER**
radioinduced vulcanization of, effects of *m*-phenyldi- and *N*-phenyl maleimides on, 17: 32167
**RUBIDIUM**
deposition from carbon dioxide on plastic or metal, 17: 32061
determination by potentiometric titration using tetraphenyl borate, 17: 31998
electron and phonon scattering on, thermoelectricity in, 17: 32785
metabolism in domestic animals, tracer study, 17: 31816(R) (ORO-605)
performance of pure vapors of, in magnetohydrodynamic cells, 17: 32817
**RUBIDIUM ALLOYS**
Cs–Rb, thermoelectricity from electron and phonon scattering on, 17: 32785
K–Rb, thermoelectricity from electron and phonon scattering on, 17: 32785
**RUBIDIUM BROMIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**RUBIDIUM CHLORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**RUBIDIUM FLUORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**RUBIDIUM IODIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
scintillation in, decay and particle-discrimination properties of, 17: 32444
**RUBIDIUM ISOTOPES**
alpha reactions (α,xn) with, excitation functions for, 17: 31797(R) (BNL-782(p.51-9))
spin exchange in collisions of, use of optical pumping methods in determining, 17: 32047 (TID-19198)
**RUBIDIUM ISOTOPES Rb-86**
use as tracer in pulp and paper research, 17: 32328
**RUMANIA**
nuclear power research in, 17: 31811
**RUTHENIUM**
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
**RUTHENIUM CHLORIDES**
preparation and properties, 17: 32122
**RUTHENIUM ISOTOPES Ru-103**
diffusion from irradiated uranium when heated in air, 17: 32287 (LF-9)

## S

**SAFETY**
during handling and laundering of beryllium-contaminated protective clothing, 17: 32291 (UCRL-7311)
nuclear, handbook, 17: 32293 (Y-1272)
radiation exposure to man by television sets and luminous dials, 17: 32309
relation to radiation protection regulations, 17: 32317
respirator program for uranium mills, 17: 32311
**SAMARIUM**
atomic M states in, widths of, 17: 32724(R) (PR-P-57(p.21-36))
determination in presence of other rare earths, spectrophotometric, 17: 32002
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
spectra of, infrared, 17: 32739
**SAMARIUM BORATES**
$LaBO_3$–$SmBO_3$, structural polymorphism of, 17: 32124
$NdBO_3$–$SmBO_3$, structural polymorphism of, 17: 32124
**SAMARIUM CHELATES**
luminescence decay times and spectra of, 17: 31980 (CONF-37-4)
**SAMARIUM CHLORIDES**
vapor pressure, 17: 32118
**SAMARIUM COMPLEXES**
with DTPA, formation and stability constants of, 17: 32110
**SAMARIUM HYDROXIDES**
thermal decomposition, 17: 32109
**SAMARIUM ISOTOPES Sm-142**
production in heavy-ion induced reactions, recoil range properties of, 17: 33094
**SAMARIUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**SAMARIUM OXIDES**
phase transformations in, 17: 32058
reactions with melted fluorides, 17: 32111
solubility in boiling water, 17: 32058
**SAMARIUM SELENIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**SAMARIUM SULFIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**SAMARIUM TELLURIDES**
crystal structure, 17: 32125
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**SAMARSKITES**
chemical properties, comparison with ampangabeites, 17: 32270
**SAMPLING**
methods of, for determining radioactive dusts, 17: 32310
**SANDS**
analysis for moisture by neutron absorption, 17: 32018
preparation of gold-198-labeled, 17: 31982
**SATELLITES**
propulsion systems for, launching and orbit transfer parameters for electrothermal arc-jet, 17: 32219
propulsion systems for control of stationary, electric, 17: 32220
semiconductor radiation detectors for Telstar, 17: 32458
**SCANDIUM**
abundance in 3 Centauri A, 17: 32851
crystal structure of, x-ray absorption spectral studies of, 17: 32589
magnetic properties of single crystals of, 17: 32640
properties of, chemical and physical, 17: 32648
separation from titanium by cation exchange chromatography, 17: 32054
**SCANDIUM ALLOYS**
properties of, chemical and physical, 17: 32648
**SCANDIUM BORIDES**
crystal structure of, x-ray absorption spectral studies of, 17: 32589
**SCANDIUM CARBIDES**
crystal structure of, x-ray absorption spectral studies of, 17: 32589
**SCANDIUM CHLORIDES**
reactions with ethylendiamine, mechanism, 17: 32147
**SCANDIUM IONS**
separation of, parameters for cation-exchange, 17: 32092
**SCANDIUM ISOTOPES Sc-48**
decay, 17: 31797(R) (BNL-782(p.51-9))
**SCANDIUM ISOTOPES Sc-49**
separation from irradiated calcium, 17: 32164
**SCANDIUM NITRIDES**
crystal structure of, x-ray absorption spectral studies of, 17: 32589
electric and optical properties, 17: 32652
**SCANDIUM NITRATES**
preparation and properties of complex, 17: 32172
solubility in water and in nitric acid and organic solvents, 17: 32115
**SCANDIUM OXIDES**
entropy, 17: 32031 (BM-RI-6245)
thermal capacity at 50 to 298°K, 17: 32031 (BM-RI-6245)
**SCATTERING**
amplitudes in inelastic, analytical properties of, 17: 32942
amplitudes, Regge-pole effects on asymptotic, 17: 32957
book: *The Optical Model in Nuclear and Particle Physics*, 17: 33108
cross sections near thresholds, in attractive Coulomb fields, 17: 33083
dispersion relations for pseudoscalar-meson elastic, 17: 32951
dispersion relations for, integration of, 17: 33229
models for high-energy, comparisons between, 17: 32952

of nuclear reaction products, chamber for observing, 17: 32393(P)
phase shifts for, ambiguity problems in, 17: 33234
phase shifts in potential, Regge-pole effects on, 17: 32956
potential, nonadiabaticity in, 17: 32967
potential, properties of relativistic two-body, 17: 32928
potential, regularity of T matrix in Dirac, 17: 32926
S-matrix for complex angular momentum and energy in, real unitary representation of many-channel, 17: 32927
T-matrices for, calculation of explicit forms and recursion relations for elements in, 17: 32919 (WAPD-T-1579)
theory, 17: 32910 (TID-7668(Sect.II))
theory of slow neutron, in magnetic crystals, 17: 32987
uniqueness of the partial wave amplitude, 17: 32904 (EFINS-63-40)
variation principles for an arbitrary operator for, 17: 33230
vector mesons as Regge poles in perturbation theory, 17: 32902 (EFINS-63-35)
wave functions for three-body interactions, two-body methods for, 17: 32922

**SCINTILLATION DETECTORS**
description of low-background, for radon measurements, 17: 32459
design for discrimination between particles of differing ionization power, 17: 32426
design for low-level beta activity, 17: 32410
design of for radon monitoring, engineering drawings for, 17: 32375
development of beta-gamma, 17: 32399 (HW-SA-2932)
development of lithium-glass, for neutron detection, 17: 32405 (ZFK-RN-19)
discrimination characteristics of, for different particles, 17: 32444
efficiencies and photofractions of cylindrical thallium-activated sodium iodide, Monte Carlo calculations of, 17: 32416
performance for charged-particle discrimination in mass spectroscopy, 17: 32428
performance in photoproton telescopes, 17: 32440
performance of plastic, optimization of light collection in, 17: 32396 (AERE-R-3972)
photofraction of cylindrical thallium-activated sodium iodide, for 0.32- to 2.76-Mev gamma radiation, 17: 32415
photomultiplier tubes for, description of, 17: 32451
preparation of discs for, by compression, 17: 32406
resolution of noble-liquid, 17: 32449
use in angular-correlation polarimeter for study of gamma-gamma cascades, 17: 32400 (KFK-129)

**SEA WATER**
analysis for niobium-95 and zirconium-95, spectrographic, 17: 32005
lead content in Mediterranean Sea, 17: 32274
radiation in, cosmic and nuclear, 17: 32718(R) (NP-12996(p.36-7))
radioisotope sorption by sedimentary particles in, 17: 31830 (TID-19127)
radiological monitoring in France, May 1963, 17: 32289(R) (SCPRI(RM)V-1963))

**SEALS AND GLANDS**
testing aluminum wire, 17: 33159(R) (ORNL-3472(p.107-18))

**SEED**
radiation and chemical effects on viability and aberrations in potato, 17: 31938
radiation effects on, environmental factors in, 17: 31869
radiation effects on corn, from satellite flights, 17: 31947
radiation effects on, environmental factors in, 17: 31951
radioinduced chromosome aberrations in barley, effects of intensity on frequency of, 17: 31902
radiosensitivity, 17: 31816(R) (ORO-605)

**SEISMIC WAVES**
shapes of, from underground explosions, 17: 32271

**SELENIUM**
analysis for trace impurities, activation, 17: 32020
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
metabolism in domestic animals, tracer study, 17: 31816(R) (ORO-605)

**SELENIUM ISOTOPES Se-80**
neutron reactions with, determination of mass-flow function from, 17: 33027

**SEMICONDUCTOR DETECTORS**
design and performance of silicon p-n junction, for Telstar, 17: 32458
design of, for alpha counting, engineering drawings for, 17: 32378
design of silicon n-p-p junction rectifier, for fast neutrons, 17: 32411
development at Chalk River, 17: 32724(R) (PR-P-57(p.21-36))
development for neutron detection, 17: 32404(R) (WCAP-2274)
pulse-height spectrum expansion for kicksorter, bias unit, 17: 32355
response to fission fragments, energy losses by atomic collisions in, 17: 32792
use for coincidence beta spectroscopy, 17: 32421

**SEMICONDUCTORS**
bibliography, 17: 32338 (NP-12989)
Faraday effect in, theory of, 17: 32701 (AERE-R-4341)
infrared radiation modulation in, by free carrier absorption, 17: 32729 (SCR-636)
radiation damage in, correlation of neutron and proton, 17: 32678
thermionic work functions of cesium–antimony, cesium–silicon, and cesium–tellurium films in cesium vapor, 17: 32830

**SEPARATION PROCESSES**
fission-product removal in nitric-acid-leach process in reprocessing uranium dioxide-dispersed graphite fuels, 17: 32200
performance of halide- and oxide-reduction, for reactive metals, 17: 32504
survey of halogenation methods for irradiated reactor fuels, 17: 32199

**SERVOMECHANISMS**
development for use in radiation-resistant pneumatic power systems for space vehicles, 17: 32208(R) (GDC-63-140)

**SF MATERIALS ACCOUNTING**
management by reactor operators, 17: 33269

**SHERWOOD PROJECT**
cryogenics, 17: 33149(R) (NBS-7919)

**SHIELDED CONTAINERS**
design for shipping irradiated fuel elements, 17: 32303

**SHIELDING**
calculations of, for Hanford Pot Calcination Demonstration, 17: 33397 (ORNL-TM-595)

**SHIELDING MATERIALS**
properties of lead as, effects of impurities on, 17: 33256
testing of high-density slag concrete as, 17: 33222 (ORNL-3473)

**SHIPPING**
shipper-receiver differences in, 17: 32315

**SHIPPINGPORT PRESSURIZED WATER REACTOR**
operating experience, 17: 33361
radiation survey of reactor vessel head, core 1, seed 3, 17: 33306 (DLCS-3050123)

**SHOCK WAVES**
base pressure analysis under conditions of missile flight through, 17: 32730 (TID-19116)
front structure in atomic hydrogen, effects of Lyman continuum radiation on, 17: 32744
production by sparks in gases, 17: 32801
propagation of, from underground thermonuclear explosion, long-range, 17: 31801 (PNE-202F)
radiations behind, in air and nitrogen, 17: 32705 (BSD-TDR-63-102)
shock strength vs. area variations in channels containing monatomic conducting fluids, 17: 32742

**SILICATES**
radiation effects on organic, cosmic, 17: 32693
sorptive properties for cesium and strontium, 17: 32045(R) (TID-19184)

**SILICON**
alpha reactions (α,n) with, neutron yields from, 17: 33017
alpha reactions (α,n) with, neutron yields from, 17: 33018
determination in coal by nuclear techniques, 17: 31985 (CONF-124-1)
determination in gallium arsenide, activation, 17: 32004
effects on reduction of niobium alloys, 17: 32492
impregnation of graphite with, *in vacuo*, 17: 32554
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
reactions with uranium tetrafluoride, 17: 32182(R) (GTR-17)

**SILICON CARBIDES**
radiation effects on diodes of, 17: 32404(R) (WCAP-2274)
graphite–SiC, production of high thermal resistance, 17: 32554

**SILICON CRYSTALS**
radiation damage in semiconducting, correlation of neutron and proton,

17: 32678
**SILICON ISOTOPES Si-28**
alpha elastic and inelastic scattering at 22.5 Mev, differential cross sections for, 17: 33101
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
energy levels of, parity and spin of resonance, 17: 33045
energy levels of, spin assignments for, 17: 33012
**SILICON ISOTOPES Si-29**
neutron reactions (d,p) with, cross sections and energy levels of, 17: 33066
**SILICON ISOTOPES Si-30**
energy levels of, spin assignments for, 17: 33012
**SILICON ISOTOPES Si-32**
gamma reactions (γ,n) at 26.5 Mev, photoneutron spectra, 17: 33032
**SILICON JUNCTIONS**
design and performance of n-p-p, for fast neutron dosimetry, 17: 32411
performance of p-n, in logarithmic amplifiers, 17: 32349
radiation effects on, neutron, 17: 32680
**SILICON OXIDES**
analysis for aluminum, spectrophotometric, 17: 32028
fabrication and properties of slip-cast fused, 17: 32488(R) (TID-19057)
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
nuclear magnetic resonance relaxation in water vapor sorbed in, temperature dependence of, 17: 32134
separation of zirconium oxide from, as function of $SO_3$–$ZrO_2$ ratio, 17: 32077
BaO–$Cs_2O$–$La_2O_3$–$Li_2O$–$SiO_2$, electrochemical properties of, effects of added oxides on, 17: 32098
BaO–$La_2O_3$–$Li_2O$–$SiO_2$, electrochemical properties of glass, 17: 32097
$Cs_2O$–$La_2O_3$–$Li_2O$–$SiO_2$, electrode properties of glass, 17: 32096
**SILICON STEEL**
Mn–Si, radiation effects on plastic deformation of, 17: 32684
**SILICON SYSTEMS**
Fe–Nb–Si, effects of carbon content on properties and reduction of, 17: 32492
**SILICONE POLYMERS**
radioinduced crosslinking of methyl, effects on nuclear magnetic resonance spectra of, 17: 32682
**SILICONE RUBBERS**
radioinduced vulcanization of, effects of *m*-phenyldi- and *N*-phenyl maleimides on, 17: 32167
**SILICONES**
radiation effects on, cosmic, 17: 32693
**SILTS**
analysis for hafnium and zirconium, neutron activation, 17: 31986 (TID-19179)
survey of bottom sediments of Bogue Sound area, North Carolina, 17: 31817(R) (TID-19122)
**SILVER**
diffusion and electric mobility in bismuth, 17: 31798(R) (BNL-782 (p.60-91))
effects of, on shielding properties of lead, 17: 33256
ion exchange with aluminum and sodium on Dowex 50W resin, rate of, 17: 32053
neutron capture cross section at 24 Mev, 17: 33005 (ORNL-TM-636)
proton fission at 19 Bev, lithium-8 from, 17: 33081
radiation effects on plastic deformation of, 17: 32684
wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445 (p.199-217))
**SILVER ALLOYS**
Ag–Ta, preparation and properties of impregnated, 17: 32495
Cu–Ag, brazing of graphite to, 17: 32547
Nb–Ag, preparation and properties of impregnated, 17: 32495
Ni–Ag, production of, by sintering at 470 to 1150°C, 17: 32497
**SILVER CHLORIDE CRYSTALS**
fluorescence of doped and pure, blue-green emission band shift in, 17: 32161
**SILVER FILMS**
electron reactions with, emission spectra from, 17: 32669 (ORNL-3450)
**SILVER IONS**
fluorescence of silver chloride crystals doped with, blue-green emission band shift in, 17: 32161
**SILVER ISOTOPES Ag-105**
decay scheme, 17: 33028
**SILVER ISOTOPES Ag-110**
neutron capture cross section of metastable, 17: 33026
**SINTERING**
mechanisms of, in crystalline powders, 17: 32542(T) (UCRL-Trans-953(L))
shrinkage in, non-uniform, 17: 32582
**SKELETON**
calcium-45 and strontium-90 uptake by rat, effects of stable strontium on, 17: 31831(T) (JPRS-19626)
radiation effects on cytochromoxidase and succinic dehydrogenase activity in rabbit, fractionated gamma and x-ray, 17: 31979
**SKIN**
ionization reactions with electromagnetic radiation, 17: 31871
radiation effects on absorption of iodine-131-labeled sodium iodide by rat, 17: 31957
radiotherapy using electron beams, 17: 31824
**SLAGS**
analysis for niobium and tantalum, fluorescence spectrometric, 17: 32007
**SNOW**
lead content in, 17: 32274
lead isotopic composition in, 17: 32274
**SODIUM**
alpha reactions (α,n) with, neutron yields from, 17: 33017
alpha reactions (α,n) with, neutron yields from, 17: 33018
boiling of liquid, acoustic noise production in nucleate, 17: 32251 (TRG-Report-549)
corrosive and structural effects on chromium-molybdenum carbon steel and type 316 stainless steel at 1100 and 1200°F, 17: 32571(R) (MSAR-63-105)
corrosive effect, 17: 31798(R) (BNL-782(p.60-91))
density of vapors of, use of interferometric and optical pumping techniques in measuring, 17: 32047 (TID-19198)
determination in natural diamonds, activation, 17: 31995
determination in sodium tungsten bronze, activation, 17: 31994
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
dietary levels of, effects on retention of cesium-137, 17: 31836
dissolution of stainless steel-clad, in nitric acid, electrolytic, 17: 32192(R) (DP-839)
electric resistivity of, for reducing impurity-type, 17: 32843(P)
electronic structure, 17: 32659
heat transfer from flowing, to stainless-steel tube, 17: 32253
ion exchange with silver and zinc on Dowex 50W resin, rate of, 17: 32053
performance of pure vapors of, in magnetohydrodynamic cells, 17: 32817
**SODIUM BROMIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**SODIUM BROMIDES**
$Ba(NO_3)_2$–NaBr, phase studies, 17: 32112
**SODIUM BRONZE**
Na–W, analysis for sodium, activation, 17: 31994
**SODIUM CHLORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**SODIUM CHLORIDES**
effects on ammonia yield in radiolysis of cystine, 17: 32158
reactions with cerium chlorides, 17: 31795(R) (BNL-782(p.18-43))
$BaCl_2$–LiCl–NaCl, phase studies, 17: 32120
**SODIUM FLUORIDE CRYSTALS**
cohesive energy of, Born analysis for, 17: 32084
**SODIUM FLUORIDES**
KF–NaF, reactions with cerium, neodymium and samarium oxides at 900 to 1100°C, 17: 32111
**SODIUM IODIDE CRYSTALS**
angular correlation attenuation coefficients for photopeaks measured by, 17: 32427
cohesive energy of, Born analysis for, 17: 32084
photofraction of cylindrical thallium-activated, for 0.32- to 2.76-Mev gamma radiation, 17: 32415
**SODIUM IODIDES**
radiation effects on absorption of iodine-131-labeled, by rat skin,

17: 31957
**SODIUM ISOTOPES Na-22**
beta spectra measurements by solid-state detectors, 17: 32421
positron spectra, 17: 32424
production in neutron fission of uranium (IV) fluoride, 17: 33030
**SODIUM ISOTOPES Na-23**
deuteron reactions (d,p) at 7.8 Mev, 17: 33055
**SODIUM ISOTOPES Na-24**
energy levels up to 7 Mev, 17: 33055
use as tracer in pulp and paper research, 17: 32328
**SODIUM NITRATES**
$BaBr_2$–$NaNO_3$, phase studies, 17: 32112
**SODIUM OXIDES**
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
**SODIUM PYROPHOSPHATES**
KF–$Na_4P_2O_7$, phase studies, 17: 32114
**SODIUM THIOSULFATES**
radiation effects on electron magnetic resonance in, gamma, 17: 32166
radiation effects on electron spin resonance spectra of, 17: 32746
**SODIUM XENATES**
Mössbauer effect in, 17: 32089
**SOILS**
chemical reactions with fission products, 17: 31816(R) (ORO-605)
radioactivity of, measurements of gamma, 17: 32264 (UCRL-10636)
sorption of radioisotopes by, 17: 33409
**SOLAR FLARES**
effects of, review of geophysical, 17: 32871
effects on ionospheric cosmic-noise absorption and enhancements, similarity of, 17: 32857
magnetic field annihilation and reconnection in, 17: 32859
measurements of type III and III , photometric and positional, 17: 32875
production of, effects of plasma instabilities on, 17: 33166
**SOLAR RADIATION**
description of type IV r-f, 17: 32877
effects on geomagnetic fields, during magnetic storms, 17: 32864
emission of r-f, frequency drift of type III, 17: 32855
intensity variations of nuclei and protons in, diffusion model for, 17: 32885
interactions with Martian atmosphere, biological implications of neutron production in, 17: 32881
reactions in terrestrial atmosphere, fluorescence from photon, 17: 32873
**SOLENOIDS**
degradation effect of superconducting, theory of, 17: 33158(R) (ORNL-3472(p.84-106))
**SOLIDS**
catalytic effects of nonmetallic, in presence of radiation, 17: 32178
electromagnetic wave interactions with, electric and thermal effects of, 17: 32674
heating by electron bombardment, calculation of surface temperature in, 17: 32821
radiation effects on properties of, neutron, 17: 32694
**SOLVENTS**
solvent properties for plutonium, literature survey on, 17: 32190 (DP-700)
**SONIC INSPECTION**
measurement of grain size in outer annular region of metal bars by, 17: 32263(P)
**SOUND**
velocity in plasma, ionic, 17: 33153(R) (ORNL-3472(p.24-49))
**SOVIET UNION**
welding development in, 17: 32541(T) (FTD-TT-62-1677)
**SPACE**
environmental effects of, simulation of, 17: 32884 (ASDC-TDR-63-118)
propulsion systems for, nuclear, 17: 33386
radiation effects in, NASA laboratory for studies of, 17: 32699
**SPACE FLIGHT**
mission capabilities of electric propulsion for, 17: 32223
mission parameters for Jupiter orbit, using electric propulsion, 17: 32221
propulsion requirements for Jupiter and Mars orbital, electric, 17: 32210
propulsion systems for Mars and Venus mission, parameters for electric, 17: 32222
propulsion systems for Mars missions, comparison of chemical, electrical, and nuclear upper-stage, 17: 33384
propulsion systems for, survey of, 17: 33387
**SPACE VEHICLES**
construction of, use of beryllium in, 17: 32485 (MAB-193-M)
power plants for, description of nuclear-electrogenerator, 17: 33391
power plants for unmanned, performance of SNAP-8 for, 17: 33392
power supplies for, entropy production and performance of magnetohydrodynamic, 17: 32824
power systems for, development of radiation-resistant pneumatic, 17: 32208(R) (GDC-63-140)
propulsion by plasma guns, design problems in, 17: 32225
propulsion of, performance of cerium-144 electrostatic system for, 17: 33390
propulsion systems for, eccentricity and inclination changes effected by low-thrust, 17: 32218
propulsion systems for, Jupiter orbit parameters for electric, 17: 32221
propulsion systems for Mars and Venus mission, parameters for electric, 17: 32222
propulsion systems for, using superconducting magnets, 17: 32224
radiation effects on, NASA laboratory for studies of, 17: 32699
radiators for, materials selection for, 17: 33393
**SPARK DETECTORS**
characteristics of parallel-plate and triggered multi-wire, 17: 32442
development of sonic-chamber, and scanning equipment, 17: 32915 (TID-7668(Sect.VII))
particle track location in multi-wire, accuracy of, 17: 32443
performance for fission fragment detection in alpha background, 17: 32403 (UCRL-7169)
use of high-resistance electrodes in, for high efficiency in many-particle detection, 17: 32417
**SPECTRA**
bibliography and review of vibrational, of molten salts, 17: 32041 (ORNL-3413)
**SPECTRAL SHIFT CONTROL REACTOR**
description and economics, 17: 33349
**SPECTROMETERS**
development for neutron-charged particle reactions, 17: 31797(R) (BNL-782(p.51-9))
magnets for, pole shaping for strong- and weak-focusing, 17: 31791
transmission of $\sqrt{2}\pi$, 17: 32727(R) (PR-P-57(p.69-85))
**SPECTROSCOPY**
background from superposed pulses in nuclear, device for reducing, 17: 32441
method for obtaining comparable photographs of an oscilloscope display in analysis by the gray-wedge technique in, 17: 32464(P)
**SPERMATOGENESIS**
mutagenic effects of formaldehyde food and x rays in, of Drosophila, 17: 31892
radiation effects on, from ingested strontium-90 in dogs, 17: 31929
radiation effects on occurrence frequencies of mutations in, 17: 31936
radiation effects on chromosomal rearrangement in, in monkeys, 17: 31950
radiation induced mutational rate, in *Drosophila melanogaster*, 17: 31894
**SPHERES**
heat and mass transfer measurements in beds of, 17: 33326(R) (ORNL-3445(p.298-328))
motion of conducting and non-conducting, through conducting fluid in transverse magnetic field, 17: 32784
motion of non-conducting, through conducting fluid in transverse magnetic field, 17: 32783
superconductivity hollow, magnetic field effects on, 17: 32809
**SPLEEN**
radiation effects on cells of, in tissue culture, 17: 31946
radiation effects on DNA, nucleoproteins, and RNA content in, in chicken, 17: 31955
**SPONTANEOUS FISSION**
fragments from, shell influence on, 17: 32723(R) (PR-P-57(p.5-20))
**STABLE ISOTOPES**
abundance, 17: 32709 (IFA/SN/17)
neutron capture cross sections, thermal, 17: 32709 (IFA/SN/17)
**STACK DISPOSAL**
of iodine-131, monitoring, 17: 32284 (DPSPU-63-30-26B)

**STAINLESS STEEL**
bursting of cladding tubes of, in loss-of-coolant accident in boiling and pressurized water reactors, 17: 32620
coating by zirconium from vapor of iodides, 17: 32507
coating of, by plasma-arc spraying, 17: 32545
coating with cesium and rubidium by deposition from carbon dioxide, 17: 32061
compatibility with graphite, 17: 33324(R) (ORNL-3445(p.218-50))
corrosion by hydrofluoric-nitric acid, effects of boron-10 on, 17: 32517 (RFP-307)
corrosion cracking of precipitation-hardening, 17: 32531
decontamination by oxalate–peroxide solutions, 17: 33318(R) (ORNL-3445(p.30-6))
decontamination by oxalate–peroxide solutions, 17: 33322(R) (ORNL-3445(p.138-98))
dissolution in nitric acid solutions, electrolytic, 17: 32192(R) (DP-839)
fabrication as forged fuel chambers for Canadian nuclear power, 17: 33333
heat transfer to, by flowing sodium, 17: 32253
hot shortness of type 347, effects of titanium and zirconium on, 17: 32628
oxidation of nitrided type 304, by EGCR coolant conditions, 17: 33319(R) (ORNL-3445(p.37-62))
physical properties of type 316, effects of air, helium, and sodium at 70 and 1200°F on, 17: 32571(R) (MSAR-63-105)
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
radiation effects on corrosion, mechanical, physical and thermal properties of, 17: 32679
stress-corrosion cracking of austenitic, effects of water environment on, 17: 32529
stress corrosion of Type 304, by heavy water, 17: 32516 (DPSPU-62-30-26)
welding for mildly corrosive nonradioactive service, specifications for, 17: 32540 (TID-19161)
welding of sheaths of, equipment, parameters, and techniques for resistance-seam, 17: 32549
**STAINLESS STEEL (AUSTENITIC)**
diffusion of carbon in, from ferritic steel, 17: 33323(R) (ORNL-3445 (p.199-217))
thermal-stress-fatigue testing of types 304 and 304-L, 17: 32566(R) (ATL-A-137)
**STAINLESS STEEL COMPACTS**
stainless steel-$UO_2$, fabrication and properties of cylindrical and tubular fuel elements of, 17: 33276
**STARS**
element abundances in $\zeta$ Herculis and G dwarfs, 17: 32852
energy of white dwarf models of, total, 17: 32858
evolution of central, in planetary nebulae, 17: 32849
evolution of, effects of neutrino processes on late stages of, 17: 32850
neutron capture processes in, element synthesis by, 17: 32883
nuclear synthesis in, by fast-neutron capture, 17: 32869
radio emission sources, identification of, 17: 32847
spectra of 3 Centauri A, element abundances from ultraviolet, 17: 32851
supernova processes in, neutron stars as remnants of, 17: 32880
**STATISTICS**
quantum, evolution to equilibrium for a simple model, 17: 33231
stationary-state solutions to Boltzmann equation, 17: 32766
**STEAM**
heat conductivity of deuterated and normal, at 100 to 500°C, 17: 32076
separation from water, development of centrifugal separators for, 17: 32206(R) (ACNP-63021)
steam-water, heat transfer of, in round vertical tubes, 17: 32244 (EURAEC-637)
steam–water, heat transfer to, flowing in round vertical tubes with non-uniform axial power distribution, 17: 32245 (EURAEC-671)
steam-water, void fraction measurements in, by gamma attenuation techniques, 17: 32241(R) (ACNP-63020)
steam–water, effects of geometrical factors on dryout of flowing, 17: 32260
**STEAM ENGINEERING**
steam-cycle performance, influence on nuclear power costs, 17: 33356
**STEAM POWER PLANTS**
design and cost of fossil-fueled, forecast of trends in, 17: 32214
**STEEL**
analysis for aluminum, spectrophotometric, 17: 32028
annealing of ingots of, electron beam for strip, 17: 32822
brazing, plating, ultrasonic testing, and welding of, used for reactor components, 17: 33260
corrosion cracking of high-strength, 17: 32531
diffusion of carbon from ferritic, to austenitic stainless steel, 17: 33323(R) (ORNL-3445(p.199-217))
embrittlement and permeation of SAE 4130, by deuterium and hydrogen, 17: 32521
embrittlement by deuterium and hydrogen, effects of gas content on SAE 4130, 17: 32522
grain size in, effects of zirconium and its carbides, nitrides, and oxides on austenitic, 17: 32627
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
radiation effects on corrosion, mechanical, physical and thermal properties of, 17: 32679
surface tension of Armoc, effects of cerium and lanthanum on, 17: 32581
x-ray absorption data for, 17: 32610
**STELLARATORS (B-3)**
plasma diffusion and properties in, 17: 33145 (MATT-157)
**STILBENE**
luminescence, decay of slow component of, 17: 32426
**4,4'-STILBENEDIOL, $\alpha,\alpha'$-DIETHYL-**
reaction of normal and malignant tissues to, 17: 31939
**STRANGE PARTICLES**
production in antinucleon annihilation and meson ($\pi$)-nucleon interactions, 17: 32920
**STRATOSPHERE**
analysis for bomb-produced beryllium-7 and strontium-89, 17: 32759
**STRESS ANALYSIS**
of nuclear reactor pressure vessel, 17: 33252
**STRONTIUM**
deposition in bone, effects of fluoride content, tracer study, 17: 31841
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
effects on uptake of calcium-45 and strontium-90 in rat skeleton, 17: 31831(T) (JPRS-19626)
metabolism in domestic animals, tracer study, 17: 31816(R) (ORO-605)
sorption by aluminum oxides and silicates, 17: 32045(R) (TID-19184)
sorption by ferric silicate, 17: 32046(R) (TID-19185)
vapor pressure at 400 to 600°C, tracer study of, 17: 32050(T) (AEC-tr-5911)
**STRONTIUM FLUORIDE CRYSTALS**
surface energy of {110} face of, calculation of, 17: 32749
**STRONTIUM ISOTOPES**
determination in environmental samples, radiochemical, 17: 32282 (AECL-1745)
migration and sorption in soil, 17: 33409
**STRONTIUM ISOTOPES Sr-88**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
**STRONTIUM ISOTOPES Sr-89**
determination of bomb-produced, in lower stratosphere, 17: 32759
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
yields from spontaneous fission of uranium-238, 17: 33109
**STRONTIUM ISOTOPES Sr-90**
absorption from lung, 17: 31835
adsorption from waste solutions, ion exchange, 17: 33408
content in atmosphere over Atlantic Ocean, March 8 to July 2, 1961, 17: 31844
content in bones of domestic animals, Japan, 1957 to 1962, 17: 32300
content in foods and in man, 1961, 17: 31846
distributions in oceans, vertical, 17: 32273
effects of radiation from ingested, on spermatogenesis, in dogs, 17: 31929

from fallout, biological availability for human populations, 17: 31839
precipitation, from highly radioactive waste solutions, 17: 33401
separation from high-level wastes, 17: 33395 (HW-SA-2786)
uptake by rat skeleton, effects of stable strontium on, 17: 31831(T) (JPRS-19626)
yields from spontaneous fission of uranium-238, 17: 33109
**STRONTIUM STANNATES**
tin-119 Mössbauer spectra in, 17: 32107
**STRUCTURES**
fallout protection afforded by, 17: 31804 (WT-1462)
**STYRENE POLYMERS**
labeling with tritium by gas-exposure method, 17: 32152 (CONF-14-21)
proton dynamic polarization in, 17: 32779
radiation effects of beta particles from tritium decay in labeled, 17: 32152 (CONF-14-21)
radioinduced graft polymerization of, to cellulose in red pine sapwood, 17: 31807
radioinduced graft polymerization of, to cotton cellulose and rayon, effects of solvent additives and water on, 17: 31808
radiolysis, 17: 32176
shielding properties of, 17: 33256
**STYRENES**
graft polymerization of, on cellulose acetate, ceric ion, preirradiation, and radiation methods for, 17: 31809
radiation effects on, cosmic, 17: 32693
radiation polymerization of, 17: 31796(R) (BNL-782(p.44-50))
radioinduced graft polymerization of, to viscose rayon yarn, optimum conditions for, 17: 32676
radioinduced polymerization with maleic acid, phthalic acid, and propylene glycol esters, 17: 32177
**SUCCINIC DEHYDROGENASE**
radiation effects on activity of, in liver, nervous system, and skeleton in rabbits, 17: 31979
**SUCROSE**
polymerase–DNA complex in gradient of, 17: 31832
**SULFIDE CRYSTALS**
sulfur-35 exchange between hydrogen sulfide and, 17: 32138
**SULFIDE IONS**
fluorescence of silver chloride crystals doped with, blue-green emission band shift in, 17: 32161
**SULFIDES**
radiation effects on organic, cosmic, 17: 32693
**SULFITES**
effects on enzymatic activity of irradiated pepsin, 17: 31940
**SULFUR**
alpha reactions (α,n) with, neutron yields from, 17: 33017
**SULFUR COMPOUNDS**
protective effects against radiation injuries in rats, effects of sulfur content on, 17: 31943
**SULFUR ISOTOPES S-32**
energy levels of, spin assignments for, 17: 33012
**SULFUR ISOTOPES S-33**
energy levels of, spins and transition correlations of, 17: 32725(R) (PR-P-57(p.37-43))
**SULFUR ISOTOPES S-34**
energy levels of, spin assignments for, 17: 33012
**SULFUR ISOTOPES S-35**
exchange between hydrogen sulfide and sulfide crystals, 17: 32138
separation from organic reactor coolants, by adsorption, 17: 33280
use as tracer in pulp and paper research, 17: 32328
**SULFURIC ACID**
oxidation of zirconium, anodic current strength in, 17: 32528
**SUN**
magnetic field of, parameters for, 17: 32879
magnetic field production in photosphere of, kinetic theory of, 17: 32854
radio bursts in corona of, frequency drift of type III, 17: 32855
spectra of, intensity and velocity fluctuations of calcium K line in, 17: 32856
**SUPERCONDUCTIVITY**
in manganese–titanium alloys, 17: 32706 (CONF-23-19)
magnetic field effects on, in hollow cylinders and spheres, 17: 32809
transition point of, pressure effects on, 17: 32806
variational problems in, projection operators for, 17: 32738
**SUPERCONDUCTORS**
current flow in, of the second kind, model for longitudinal force-free, 17: 32741
development at ORNL, 17: 33158(R) (ORNL-3472(p.84-106))
electric current in, electron depairing effects on, 17: 32839
magnetic properties, 17: 32712 (LNF-63/26)
properties of niobium–thorium eutectic alloys, 17: 32650
**SUPERFLUIDITY**
stability of rotatory flows in, 17: 32808
**SUPERHEATERS (NUCLEAR)**
fuel cladding failure in, effects of strain cycling on, 17: 33239 (GEAP-4244)
review of programs and concepts, 17: 33353
**SURFACE FRICTION**
measurement between bearing materials, survey of, 17: 32208(R) (GDC-63-140)
measurement in gas-cooled and pebble-bed reactors, 17: 33326(R) (ORNL-3445(p.298-328))
**SURFACE WATERS**
analysis for tritium during nuclear test moratorium, 17: 32758
**SWEDISH REACTORS (R-3)**
design description, 17: 33350
**SWIMMING POOL REACTORS**
criticality studies of Advanced Pressure Tube Reactor, hazards evaluation for, 17: 33373 (NP-12998)
**SWINE**
radiation effects, whole-body nuclear exposure, 17: 31816(R) (ORO-605)
**SWITCHES**
response of thermal, for magnet coil cooling system, 17: 33158(R) (ORNL-3472(p.84-106))
**SYNCHROTRONS**
development of electron, worldwide, 17: 32917 (TID-7668(Sect.IX))
oscillations in strong-focusing, calculation of damping constants of horizontal, 17: 33117 (LNF-63/18)
radiofrequency system design for AdA, 17: 33116 (LNF-63/10)
**SYSTEMS FOR NUCLEAR AUXILIARY POWER (SNAP-8)**
reactor and shield design for, 17: 33392
**SZILARD-CHALMERS REACTIONS**
in potassium nitrosylopentacyanomanganate, 17: 32168

# T

**TANTALATES**
preparation and crystal structure, 17: 32100
**TANTALUM**
alloying effects on mechanical properties of aluminum alloys, 17: 32608
cesium ionization on, efficiency of, 17: 32825
coating of, effects of, on compression and high-temperature damage and oxidation, 17: 32526
crystal structure, 17: 32565 (ASD-TR-61-181(Pt.III))
determination by x-ray fluorescence, 17: 31999
determination in alloys, ores, and slags, fluorescence spectrometric, 17: 32007
determination in ores, spectrometric-scintillation counting, 17: 32025
gamma reactions on, distributions of neutrons from, 17: 33074
mechanical properties, 17: 32565 (ASD-TR-61-181(Pt.III))
nuclear shapes and sizes in, 17: 33073
properties and separation processes for, review on, 17: 32508
solubility in mercury, 17: 31798(R) (BNL-782(p.60-91))
**TANTALUM ALLOYS**
Ag–Ta, preparation and properties of impregnated, 17: 32495
Cu–Ta, preparation and properties of impregnated, 17: 32495
**TANTALUM CARBIDES**
coating of, by plasma-arc spraying, 17: 32545
sintering without binder, pressure, 17: 32583
thermal decomposition, 17: 32036 (CONF-40-2)
TaC–UC, carbon-stable regions in, 17: 32617
**TANTALUM ISOTOPES Ta-181**
energy levels, 17: 32991 (ANL-6727)
neutron scattering at 0.3 to 1.5 Mev, angular distributions and energy-level excitations in, 17: 32991 (ANL-6727)

**TANTALUM OXIDES**
determination by x-ray fluorescence, 17: 31999
preparation and crystal structure of ternary, 17: 32100
**TECHNETIUM**
oxidation states of, chemistry of, 17: 32137
**TEETH**
analysis for radium-226 traces, scintillation, 17: 32459
analysis for radium uptake, 17: 32314
**TELLURIUM**
determination of traces in selenium, activation, 17: 32020
**TELLURIUM ISOTOPES Te-125**
nuclear electric quadrupole moment of 35-kev state of, 17: 33007 (UCRL-7297)
**TELLURIUM ISOTOPES Te-132**
diffusion from irradiated uranium when heated in air, 17: 32287 (LF-9)
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
**TEMPERATURE**
measurement through vessel walls with no direct connections, 17: 32230(P)
radiosensitivity effects on seeds, 17: 31869
radiosensitivity effects on plants, 17: 31951
rate of mutational response controlled by, in *Drosophila melanogaster*, 17: 31894
**TERBIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
**TERBIUM ALLOYS**
Tb–Zr, magnetic properties of, 17: 32651
**TERBIUM CHELATES**
luminescence decay times and spectra of, 17: 31980 (CONF-37-4)
**TERBIUM CHLORIDES**
vapor pressure, 17: 32118
**TERBIUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**TERBIUM SELENIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**TERBIUM SULFIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081
**TERBIUM TELLURIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**TERPHENYL**
luminescence, decay of slow component of, 17: 32426
pyrolysis and radiolysis of, review on, 17: 32165
**TETRACYCLINE**
effects of, on radiation effects on blood cells in chicks, 17: 31954
**TEXTILES**
radioinduced graft polymerization of styrene to viscose rayon yarn, 17: 32676
radioinduced polymerization of rayon, on polystyrene, effects of solvent additives and water on, 17: 31808
**THALLIUM ALLOYS**
Hg–Tl, electrode processes on, in perchlorate solution, 17: 32642
**THALLIUM BROMIDES**
LiCl–TlBr, phase studies, 17: 32113
**THALLIUM IONS**
fluorescence of silver chloride crystals doped with, blue-green emission band shift in, 17: 32161
**THALLIUM ISOTOPES Tl-199**
production in lithium-6 reactions with gold-197 at 15–40 Mev excitation functions for, 17: 33038
**THALLIUM ISOTOPES Tl-200**
production in lithium-6 reactions with gold-197 at 15–40 Mev, excitation functions for, 17: 33038
**THERMAL DIFFUSION**
column performance for separation of xenon-131 and -136, 17: 32469
**THERMAL REACTORS**
breeding ratio in plutonium-fueled, 17: 31794(R) (BNL-782(p.1-17))
**THERMIONIC CELLS**
development of, for space applications, 17: 32702 (ASD-TDR-63-442)
testing of 150-watt nuclear-fueled, heat-transfer and in-pile, 17: 32836
use of cesium compound semiconductors as collectors in, 17: 32830
**THERMOCOUPLES**
development for high-temperature measurements, 17: 33327(R) (ORNL-3445(p.329-46))
performance of graphite-rhenium, 17: 31798(R) (BNL-782(p.60-91))
research at Brookhaven, 17: 31798(R) (BNL-782(p.60-91))
**THERMODYNAMICS**
stationary-state solutions to Boltzmann equation, 17: 32766
**THERMOELECTRIC CELLS**
energy dissipation equations for, choice of coordinates in, 17: 32831
**THERMOELECTRIC MATERIALS**
properties of uranium compounds as, 17: 32587
**THERMOLUMINESCENCE**
radiation effects on, in proteins ultraviolet, 17: 31850 (AD-294395)
theories for, from macroscopic crystals, molecular crystals, and amorphous solids, 17: 31850 (AD-294395)
use for dosimetry of x-ray beams, 17: 32402(R) (TID-19112)
**THERMOMAGNETIC CELLS**
energy dissipation equations for, choice of coordinates in, 17: 32831
performance index of Nersi effect generator, boundedness of, 17: 32832
**THERMOMETERS**
design of acoustical, for wide temperature ranges, 17: 32392(P)
**THERMONUCLEAR EXPLOSIONS**
blast propagation from Sedan underground, 17: 31801 (PNE-202F)
distribution of ejecta on ground surrounding crater of underground, 17: 31802 (PNE-217F)
electrons from high-altitude, properties of geomagnetically trapped, 17: 32845 (UCRL-7309(Rev.I))
stratospheric distributions of beryllium-7 and strontium-89 from, 17: 32759
transuranium element production in, 17: 32733 (UCRL-7314(Rev.I))
**THERMONUCLEAR REACTORS**
development at ORNL, 17: 33150(R) (ORNL-3472)
electron accelerator for astron, 200-amp, 17: 33119 (UCRL-7408)
**THICKNESS GAGES**
design of beta, engineering drawings for, 17: 32372
**THORIUM**
analysis for oxygen, activation, 17: 31992
determination by EDTA titration, 17: 31993
determination in rocks and soils by radioactivity measurements, 17: 32264 (UCRL-10636)
determination in solutions, photographic, 17: 31988(T) (CEA-tr-A-1197)
determination in uranium, spectrophotometric, 17: 32027
determination in water solutions by beta absorption, 17: 32014
electrorefining of commercial, by chloride and fluoride salt baths, 17: 32499
separation from acid-ether solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from titanium by cation exchange chromatography, 17: 32054
separation from uranium by anion exchange in ketone media, 17: 32194(R) (TID-19068)
**THORIUM ALLOYS**
Mg–Mn–Th, effects of alloying agents on mechanical properties of, 17: 32595
Mg–Th, properties and structure of, alloying effects of manganese and zirconium on, 17: 32596
Nb–Th, superconducting properties of eutectic, 17: 32650
Th–W, chemical, mechanical, and thermionic properties of, 17: 32639
**THORIUM CARBIDES**
fabrication of, by continuous casting and electron bombardment for shaping nuclear fuels, 17: 33278
thermal stability of, in graphite matrices, 17: 32570 (GA-2880)
**THORIUM FLUORIDES**
formation of, free energy of, 17: 31795(R) (BNL-782(p.18-43))
**THORIUM ISOTOPES**
neutron fission of, average number of fission neutrons in, 17: 33016
**THORIUM ISOTOPES Th-228**

determination at natural levels, development of equipment for, 17: 31984 (CONF-16-1)
**THORIUM OXIDE CRYSTALS**
point defect sites in, internal friction peak from symmetry splitting of equivalent, 17: 32607
**THORIUM OXIDES**
electric conductivity of, for use as insulation in thermocouples, 17: 32644
Ni–$ThO_2$, corrosion, oxidation, and strength of, 17: 32501
**THORIUM(IV) OXIDES**
deposition on borides by pyrohydrolysis of thorium chloride, 17: 32564 (ASD-TDR-63-635)
effects on electrochemical properties of glass, 17: 32098
effects on sensitivity to toxin, in monkeys, 17: 31918
self-diffusion of oxygen in, 17: 32564 (ASD-TDR-63-635)
separation from acidic solutions, process for, 17: 32189(P)
separation of, from bauxite by direct electrolysis and precipitation, economics of, 17: 32065
sintering of, material transport in, 17: 32535 (CONF-50-15)
BeO–$ThO_2$–$UO_2$, non-uniform shrinkage in sintering of, 17: 32582
$ThO_2$–$UO_2$, non-uniform shrinkage in sintering of, 17: 32582
**THORIUM SELENIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**THORIUM SULFIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**THORIUM SYSTEMS**
C–Mo–Th, phase studies on arc-melted, pressure-sintered, and vacuum-annealed, 17: 32616
**THORIUM TELLURIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
**THREONINE**
use as substitute for isoleucine growth requirement of, in Saccharomyces, 17: 31821
**THULIUM**
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
**THULIUM BORATES**
$LaBO_3$–$TmBO_3$, structural polymorphism of, 17: 32124
**THULIUM CHLORIDES**
vapor pressure, 17: 32118
**THULIUM ISOTOPES Tm-168**
decay of, conversion electrons and gamma-gamma coincidences in, 17: 33008 (ZFK-PHA-8)
**THULIUM ISOTOPES Tm-170**
beta decay of, analysis of first-forbidden, 17: 33015
**THULIUM NITRIDES**
properties of, electric and magnetic, 17: 32081
**THULIUM SULFIDES**
properties of, electric and magnetic, 17: 32081
**THYMINE**
substitution in *E. coli* DNA with 5-bromouracil, 17: 31885
substitution in phage DNA with 5-bromouracil, 17: 31886
**THYROID DISEASES**
radiodiagnosis and radiotherapy, 17: 31826
**THYROID GLAND**
iodine-131 content of bovine, in Alabama, Sept. through Dec. 1961, 17: 32313
iodine-131 deposition in, from milk and non-milk sources, 17: 31849
radiation effects on DNA, nucleoproteins, and RNA content in, in chicken, 17: 31955
**TIN**
alloying effects on corrosion and mechanical properties of zirconium, 17: 32484(R) (GEAP-4284)
effects of, on shielding properties of lead, 17: 33256
neutron radiative capture in, optical model for cross sections of, 17: 33048
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
separation from bismuth by ion exchange, 17: 32195(T) (KFK-tr-130)
**TIN ALLOYS**
Nb–Sn, physical properties of gas-phase-deposited $Nb_3Sn$, 17: 32647
Nb–Sn, properties as superconducting magnet, 17: 32712 (LNF-63/26)
$Nb_3Sn$, superconducting critical fields of, 17: 32224
Nb–Sn, superconductivity properties of $Nb_3Sn$ in, 17: 32615
**TIN FOILS**
electron reactions with, emission spectra from, 17: 32669 (ORNL-3450)
**TIN ISOTOPES**
proton reactions (p,$\alpha$) at 20.5 Mev on, cross sections, 17: 33070
**TIN ISOTOPES Sn-118**
neutron reactions with, determination of mass-flow function from, 17: 33027
**TIN ISOTOPES Sn-119**
gamma Mössbauer spectra of, in stannates, 17: 32107
**TISSUE CULTURES**
radiation effects on spleen cells in, 17: 31946
**TISSUE HOMOGENATES**
therapeutic effects of liver, spleen, or thymus, in radiation sickness in rats, 17: 31973
**TISSUES**
analysis for inorganic elements, after neutron activation, 17: 31813 (AERE-R-4309)
radiation effects on reaction to injected dyes, whole-body exposure, 17: 31924
radiation effects on metabolism of, from injected phosphorus-32, 17: 31925
radiation effects in, effects of content of copper, cobalt, and iron on, 17: 31928
reaction of normal and malignant, to chemical radioprotective compounds, 17: 31939
**TITANIUM**
abundance in 3 Centauri A, 17: 32851
deuteron-deuteron interactions on, neutron yield, 17: 32768
effects on hot shortness of type 347 stainless steel, 17: 32628
electrorefining of commercial, by chloride and fluoride salt baths, 17: 32499
preparation by electrolysis, 17: 32514(P)
separation from rare earths and other metals by cation exchange chromatography, 17: 32054
solubility in mercury, 17: 31798(R) (BNL-782(p.60-91))
spectra of, infrared, 17: 32739
**TITANIUM ALLOYS**
Be–Ti, wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445(p.199-217))
Be–Ti–Zr, brazing of graphite to, 17: 32547
Co–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
Cr–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
Fe–Mo–Ti, magnetic properties of, 17: 32651
Fe–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
Mn–Ti, localized magnetic states and superconductivity in, 17: 32706 (CONF-23-19)
**TITANIUM CARBIDES**
mechanical flow properties at high temperatures, 17: 32614
preparation of crystals of, by zone melting at 2320 to 3800°K, 17: 32590
thermal decomposition, 17: 32036 (CONF-40-2)
**TITANIUM COATINGS**
deposition and stability of, on beryllium, 17: 32574 (PWA-2184)
**TITANIUM CRYSTALS**
preparation by zone melting at 2320 to 3800°K, 17: 32590
**TITANIUM ISOTOPES Ti-46**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
energy levels of, lifetimes of, 17: 33076
neutron reactions (n,p) on, neutron dosimetry by, 17: 32294(T) (CEA-tr-A-1221)
**TITANIUM ISOTOPES Ti-48**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
energy levels, 17: 33056
**TITANIUM ISOTOPES Ti-49**

energy levels of, spins and transition correlations of, 17: 32725(R) (PR-P-57(p.37-43))
**TITANIUM OXIDE CRYSTALS**
point defect sites in, internal friction peak from symmetry splitting of equivalent, 17: 32607
**TITANIUM OXIDES**
effects on electrochemical properties of glass, 17: 32098
preparation of crystals of, by zone melting at 2320 to 3800°K, 17: 32590
preparation of hydrogen-containing, relation to metal oxide bronzes, 17: 32088
separation of zirconium oxide from, as function of $SO_3$–$ZrO_2$ ratio, 17: 32077
$TiO_2$–$UO_2$, preparation of, at high temperatures, 17: 32656
$TiO_2$–$UO_2$, reactions in, at high temperatures, 17: 32656
**TITANIUM SYSTEMS**
B–Ti, production of, by sintering at 470 to 1150°C, 17: 32497
C–Cr–Co–Ni–Ti, production of, by sintering at 470 to 1150°C, 17: 32497
**TOLUENE**
radiolysis at −75 to 100°C, gas and liquid products from, 17: 31796(R) (BNL-782(p.44-50))
**TOXICITY**
measurement in test atmospheres, design of equipment for, 17: 32292 (UR-629)
**TOXINS**
effect of botulinum, on survival of lethally irradiated mice, 17: 31901
radiation effects on sensitivity to, 17: 31921
thorium oxide effects on sensitivity to, in monkeys, 17: 31918
**TRACER TECHNIQUES (BIOLOGY)**
computer program for analyzing, 17: 32476 (UCRL-10927)
for blood platelet life span and excretion studies, 17: 31903
for study of lymph system, 17: 31852 (BNL-7137)
metabolism studies, data analysis by electronic processing, 17: 31815 (LADC-5627)
preparation of chromium-51-labeled viable lymphocytes, 17: 31917
**TRACER TECHNIQUES (CHEMICAL ENGINEERING)**
chemical engineering use in pulp and paper research, 17: 32328
**TRACER TECHNIQUES (ENGINEERING)**
measurement of flow rates by, engineering drawings of system for, 17: 32379
use for wear measurements on cylinders and piston rings, 17: 32226
use in study of rail lubrication in winter, 17: 32326
**TRACER TECHNIQUES (MEDICINE)**
development of equipment and techniques for radiocardiography studies, 17: 31818 (TID-19168)
development of equipment and techniques for radiocardiography studies, 17: 31819(R) (TID-19173)
scintillation scan data recording on magnetic tape, 17: 32351
use of arsenic-74 in localization of brain tumors, 17: 31877
use of gold-198 in, bibliography on, 17: 31814 (KFK-143)
**TRACER TECHNIQUES (METALLURGY)**
measurement of fretting corrosion and wear by, engineering drawings of system for, 17: 32380
**TRADESCANTIA**
radiation sensitivity of microspores during mitosis, 17: 31937
**TRANSISTORS**
performance of germanium and silicon diode, in logarithmic amplifiers, 17: 32349
**TRANSURANIC ELEMENTS**
production in thermonuclear explosions, 17: 32733 (UCRL-7314(Rev.I))
**TRAUMA**
induction by nuclear explosions, management and treatment of, 17: 32295(T) (JPRS-20511)
**TRIETHYLENETETRAMINE**
complexes with nickel(II), dissociation and formation of, 17: 32067
**TRITIUM**
activity of, in precipitation in Germany, 17: 32281
alpha reactions (α,γ) with, direct-capture model for, 17: 33104
incorporation in amino acids, 17: 31842
incorporation in polystyrene by gas-exposure method, 17: 32152 (CONF-14-21)
incorporation of labeled amino acids into cell nuclei, 17: 31887
monitoring in atmosphere and surface waters during nuclear test moratorium, 17: 32758
production from irradiated aluminum–lithium alloy, 17: 33110(P)
production in atmosphere by cosmic rays, 17: 32887
use as tracer in pulp and paper research, 17: 32328
use in radiometric vacuum gages, 17: 32325
**TRITONS**
binding energy and radial function potential, 17: 32930
production in high-energy proton reactions with nuclear emulsion, 17: 33091
reactions on germanium isotopes, arsenic isotopes from, 17: 33075
reactions (t,n) with hydrogen, use as neutron source, 17: 33035
reactions (t,p) with magnesium-26 at 2.7 Mev, cross section for, 17: 31797(R) (BNL-782(p.51-9))
reactions with boron-10, cross sections for, 17: 32997 (CONF-46-79)
**TUBES**
bursting of fuel-cladding, in loss-of-coolant accident in boiling and pressurized water reactors, 17: 32620
concentricity of, design of device for measuring, 17: 32239(P)
heat transfer (unsteady) of combined free and forced convection in, with constant axial temperature gradient at wall, 17: 32261
**TUMORS**
age effects on induction of mammary, in dogs, 17: 31860(R) (UCD-107 (p.30-43))
localization of iodine-131-labeled fibrinogen in rat, 17: 31820 (UR-630)
radiation effects on immune reactions to transplanted, 17: 31915
radioinduced mammary, in dogs, 17: 31860(R) (UCD-107(p.30-43))
radiosensitivity, 17: 31826
radiosensitivity, effects of injection of plasma from irradiated animals, in rats, 17: 31875
radiotherapy of, in head and neck region, radiation hazards, 17: 31872
radiotherapy with high-energy electrons, 17: 31870
reaction to chemical radioprotective compounds, 17: 31939
**TUNGSTEN**
cesium ionization on, efficiency of, 17: 32825
coating of, effects of, on compression and high-temperature damage and oxidation, 17: 32526
crystal structure, 17: 32565 (ASD-TR-61-181(Pt.III))
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
mechanical properties, 17: 32565 (ASD-TR-61-181(Pt.III))
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
properties of, for use in thermocouples, mechanical and thermoelectric, 17: 32644
ranges of argon-41 on xenon-133 in, at kev energies, 17: 32747
welding to refractory metals in ionizers, electron-beam, 17: 32557
**TUNGSTEN ALLOYS**
Mo–Nb–W–Zr, mechanical properties of warm-extruded and rolled, 17: 32567 (BMI-X-249)
Th–W, chemical, mechanical, and thermionic properties of, 17: 32639
**TUNGSTEN BRONZE**
Na–W, analysis for sodium, activation, 17: 31994
**TUNGSTEN CARBIDES**
structural analysis of, using thermal neutrons, 17: 32057
thermal decomposition, 17: 32036 (CONF-40-2)
**TUNGSTEN ELECTRODES**
cesium film behavior on, 17: 32827
**TUNGSTEN ISOTOPES W-184**
separation from other tungsten isotopes, comparison of methods for, 17: 32468 (TID-18966)
**TUNGSTEN OXIDES**
range of krypton-85 in, at 40 kev, 17: 32747
**TURBINES**
development of high-speed expander, 17: 33149(R) (NRS-7919)
**TYROSINE**
uptake by growing hairs on rats, radioautography of different ways of, 17: 31834

# U

**ULTRASONICS**

use in fatigue testing, 17: 32262 (HW-SA-2927)
use of, for decontamination of glass, inorganic materials, and polymers, 17: 32304

**ULTRAVIOLET RADIATION**
effects on brain electric activity in rabbits, 17: 31933
effects on bromouracil substituted phage, 17: 31886
effects on cells containing 5-bromouracil-substituted DNA, 17: 31885
effects on desoxyribonucleic acid, 17: 31922
effects on thermoluminescence and electron paramagnetic resonance, of proteins, 17: 31850 (AD-294395)
mutagenic effects in Aspergillus, ascospore color, 17: 31893

**UNDERGROUND EXPLOSIONS**
blast propagation from Sedan thermonuclear, 17: 31801 (PNE-202F)
seismic waves from, shapes of, 17: 32271
thermonuclear distribution of ejecta on ground surrounding crater of, 17: 31802 (PNE-217F)

**UNITED KINGDOM ATOMIC ENERGY AUTHORITY**
research programs of, ninth annual summary, 17: 31800(R) (NP-12981)

**URACIL, 5-BROMO-**
substitution for thymine in *E. coli* DNA, 17: 31885
substitution for thymine in phage DNA, 17: 31886

**URANATES**
bibliography on crystal structure and composition of, 17: 32049 (VDIT-77)

**URANIUM**
analysis for rare earths and thorium, spectrophotometric, 17: 32027
analysis for total, content of carbon in, method for, 17: 32027
determination in kerosene–tributylphosphate extracts, method for, 17: 32000
determination in rocks and soils,by radioactivity measurements, 17: 32264 (UCRL-10636)
determination in water solutions by beta absorption, 17: 32014
determination of microamounts of, spectrophotometric, 17: 32001
diffusion in liquid aluminum, 17: 32500
diffusion of fission products from irradiated, after heating in air, 17: 32287 (LF-9)
electrorefining of commercial, by chloride and fluoride salt baths, 17: 32499
etching of alpha-, anisotropy of cathodic, 17: 32602
etching of irradiated, design of remotely controlled equipment for, 17: 32213
fission of, yields of cadmium-115 isomers at 8 to 60 Mev in, proton, 17: 33024
grain growth and size in beta-treated, 17: 32538(R) (NMI-2801)
grain growth and size in beta-treated, 17: 32539(R) (NMI-2805)
grain refinement testing in outer annular region of bars, ultrasonic, 17: 32263(P)
metallurgy of, review of, 17: 32490
neutron buckling and reflector savings for, 17: 31794(R) (BNL-782 (p.1-17))
neutron cross sections of, methods for computing effective, 17: 32727(R) (PR-P-57(p.69-85))
physical properties of oriented polycrystalline, 17: 32631
production of, by sintering at 470 to 1150°C, mechanism and technique for, 17: 32497
production of, review of French industrial developments for, 17: 32183
radiation effects on plastic deformation of, 17: 32684
separation by decomposition, electrolysis, and reduction processes, 17: 32490
separation from acid-ether solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)
separation from reactor fuels, research on, 17: 31795(R) (BNL-782 (p.18-43))
separation from thorium by anion exchange in ketone media, 17: 32194(R) (TID-19068)
smelting of, casting and properties of calcium fluoride crucibles for use in, 17: 32543

**URANIUM ALLOYS**
creep, hardening, and strength of, additive effects of beryllides, carbides, and oxides on, 17: 32657
etching of irradiated, design of remotely controlled equipment for, 17: 32213
Al–U, fabrication and microstructure of castings, 17: 32500
Al–U, uranium separation from, 17: 31795(R) (BNL-782(p.18-43))
Mo–U, $\gamma$–$\gamma'$ transformation mechanism in, 17: 32605
Mo–U, heat treatment, 17: 32619
Mo–U, phase transformation, 17: 32619
Mo–U, stress corrosion cracking, 17: 32518 (Y-1417)
Pd–$U^{235}$, development, 17: 31796(R) (BNL-782(p.44-50))
U–Zr, diffusion in gamma phase, 17: 32577(T) (AEC-tr-5931)

**URANIUM CARBIDE COMPACTS**
U–UC, fabrication and properties of cold-pressed, hot-pressed, and sintered, 17: 32487(R) (NCSC-2981-4)

**URANIUM CARBIDES**
additive effects on creep, hardening, and strength of uranium alloys, 17: 32657
coating of, with graphite, development of production scale procedures for, 17: 33279
creep tests on mono-, effects of carbon content on compressive, 17: 32636
fabrication and use for fuel elements, 17: 33248
fabrication of, by continuous casting and electron bombardment for shaping nuclear fuels, 17: 33278
fabrication of dense bars of, process for industrial, 17: 32551
fabrication, properties, and radiation effects on, review on, 17: 33270
fission-gas release from irradiated arc-cast and sintered, 17: 32691
mechanical flow properties at high temperatures, 17: 32614
oxidation of mono-, by carbon dioxide at 350 to 600°C, 17: 32127
physical properties of mono-, 17: 32636
preparation from tetrafluoride by direct conversion, 17: 32182(R) (GTR-17)
preparation of, directly from uranium (IV–VI) oxides, 17: 32133
processing for uranium separation, research on, 17: 31795(R) (BNL-782(p.18-43))
properties as reactor fuel, 17: 31794(R) (BNL-782(p.1-17))
properties of, for use in nuclear reactors, 17: 33263
properties of, for use as fuel in fast or thermal reactors, 17: 33265
radiation effects on electric conductivity and lattice parameters of, 17: 32689
reactions with nitrogen, 17: 32486(R) (NCSC-2663-13)
stability and thermodynamic properties of di-, 17: 32617
thermal decomposition, 17: 32036 (CONF-40-2)
thermal stability of, in graphite matrices, 17: 32570 (GA-2880)
Cr–UC, phase studies, 17: 32637
Cr–$UC_2$, phase studies, 17: 32637
Fe–UC, phase studies, 17: 32637
Fe–$UC_2$, phase studies, 17: 32637
HfC–UC, carbon-stable regions in, 17: 32617
NbC–UC, carbon-stable regions in, 17: 32617
TaC–UC, carbon-stable regions in, 17: 32617
UC–ZrC, carbon-stable regions in, 17: 32617
UC–ZrC, graphite coating of procedure for, 17: 33279
UC–ZrC, release of fission products from fuel inserts of, 17: 33272

**URANIUM(IV) CHLORIDES**
reactions with tertiary phosphines, 17: 32064

**URANIUM COMPACTS**
thermoelectric properties, 17: 32587
U–UC, fabrication and properties of cold-pressed, hot-pressed, and sintered, 17: 32487(R) (NCSC-2981-4)

**URANIUM COMPOUNDS**
properties of, for use as nuclear fuels, 17: 33249
thermoelectric properties, 17: 32587

**URANIUM COUPLES**
Mo–U, diffusion coefficients and Kirkendall effect in, 17: 32578(T) (AEC-tr-5932)

**URANIUM DEPOSITS**
occurrence in coals, 17: 32277

**URANIUM(IV) FLUORIDES**
conversion to monocarbide, direct, 17: 32182(R) (GTR-17)
neutron fission of uranium in, production of sodium-22 in multiple, 17: 33030
reactions with silicon, 17: 32182(R) (GTR-17)

**URANIUM FOILS**
dislocation networks in annealed alpha, electron microscopic study of, 17: 32681
preparation of converter, by cathode sputtering, 17: 32770
radiation effects on annealed alpha, electron microscopic study of, 17: 32681
**URANIUM ISOTOPES**
neutron fission of, average number of fission neutrons in, 17: 33016
**URANIUM ISOTOPES U-233**
fission fragments of, prompt neutrons from, 17: 33089
fission threshold of, determination by deuteron and gamma fission, 17: 33082
neutron cross sections for, energy-differential, 17: 32994 (CONF-39-37)
neutron fission cross sections at 1.7 to 57 ev, 17: 33029
neutron fission of, poisons from, 17: 33325(R) (ORNL-3445(p.251-97))
neutron fission of, characteristics of ternary, 17: 33019
**URANIUM ISOTOPES U-235**
determination in reactor fuel elements, gamma spectrometric, 17: 32012
fission at 0.4–11.3 Mev, prompt neutron angular and energy distributions from thermal neutron, 17: 33042
fission of, investigations of triple, 17: 33030
fission threshold of, determination by deuteron and gamma fission, 17: 33082
neutron cross sections for, energy-differential, 17: 32994 (CONF-39-37)
neutron fission at 14 Mev, characteristics of ternary, 17: 33020
neutron fission cross sections, 17: 33058
neutron fission of, poisons from, 17: 33325(R) (ORNL-3445(p.251-97))
neutron fission of, characteristics of ternary, 17: 33019
**URANIUM ISOTOPES U-238**
fission products from, radiochemical studies of, 17: 33109
neutron reactions with, blocking coefficients for cross sections for, 17: 33021
neutron resonance integrals in, 17: 31794(R) (BNL-782(p.1-17))
**URANIUM LEACH SOLUTIONS (CARBONATE)**
chlorine or hypochlorite oxidation of, 17: 32188(P)
**URANIUM MINERALS**
age of, in Katanga and N. Rhodesia, 17: 32265
separation by high-tension method, behavior during, 17: 32184
**URANIUM NITRIDES**
preparation and properties of mono-, 17: 32483(R) (BMI-X-10027)
radiation effects on stability of mono-, 17: 32660 (BMI-1638)
thermal decomposition of mono-, 17: 32032 (CNLM-5066)
thermoelectric properties, 17: 32587
Fe–UN, phase studies, 17: 32637
Ni–UN, phase studies, 17: 32637
**URANIUM ORE PROCESSING PLANTS**
industrial hygiene practices, 17: 32311
respirator program, 17: 32311
technology of, in France, 17: 32183
**URANIUM ORES**
cost forecast, 17: 32186
flotation of, using fatty acids, petroleum sulfonate, and soaps, 17: 32185
**URANIUM OXALATE COMPLEXES**
composition and stability of pentacid halide, 17: 32119
**URANIUM OXIDE COMPACTS**
Al–$U_3O_8$, reactions in, 17: 32488(R) (TID-19057)
**URANIUM(IV) OXIDE COMPACTS**
fabrication by metallurgical methods, theory of, 17: 32555
fabrication of, by vibration-compaction method for use as fuel elements, 17: 33247
fabrication of small sintered spheres of, by isostatic pressing, 17: 32556
fabrication of thin plates of, by a powder rolling process, 17: 32534 (CONF-50-3)
preparation of sintered, for use as fuel in EL-4 Reactor, 17: 33271
radiation effects on, 17: 32664 (GEAP-4197)
radiation effects on sintered, to high burnup, 17: 32686
radiation effects at high temperature on microstructure of sintered, 17: 32690
Al–$UO_2$, reactions in, 17: 32488(R) (TID-19057)
$Gd_2O_3$–$UO_2$, fabrication and properties of sintered, 17: 33236(R) (ACNP-63022)
stainless steel-$UO_2$, fabrication and properties of cylindrical and tubular fuel elements of, 17: 33276
**URANIUM(IV) OXIDE CRYSTALS**
fission gas release from, 17: 33320(R) (ORNL-3445(p.63-108))
**URANIUM(IV) OXIDE POWDERS**
fabrication into thin plates by rolling process, 17: 32534 (CONF-50-3)
vibratory compaction of, effects of acceleration, binder, frequency, power, and time on, 17: 32552
**URANIUM OXIDES (STAINLESS STEEL CLAD)**
fabrication by high-temperature coextrusion, 17: 32536 (GEAP-4282)
radiation effects on, 17: 32662 (CRFD-1132)
**URANIUM(IV) OXIDES**
additive effects on creep, hardening, and strength of uranium alloys, 17: 32657
composition of stoichiometric, relation of lattice parameters to, 17: 32131
developments in technology of, review on, 17: 33274
diffusion of xenon-133 from powders and spheroids of irradiated, 17: 32563 (AERE-R-4347)
dissolution in NOF · 3.1 HF, 17: 31795(R) (BNL-782(p.18-43))
fabrication, properties, and radiation effects on, review on, 17: 33270
grain growth of, effects of stoichiometry on rate of, 17: 32600
grain growth of sintered, at 1550 to 2100°C, 17: 32586
neutron buckling and reflector savings in matrices of, 17: 31794(R) (BNL-782(p.1-17))
production of, for sintering, 17: 33277
properties of, electrical-magnetic, 17: 32726(R) (PR-P-57(p.44-68))
properties of, for use in nuclear reactors, 17: 33263
radiation effects on thermal conductivity of, 17: 32661 (CRDC-1143)
radiation effects on sintered pellets of, electron microscopic and film replication techniques for studying, 17: 32670 (ZFK-WF-21)
radiation effects on thermal conductivity of sintered, at 200 to 1200°C, 17: 32698
radiation effects on nuclear fuel properties of, 17: 33264
radiation effects on thermal conductivity of, 17: 33361
recrystallization of, at high temperatures, 17: 32126
sintering effects on, Pines theory of, 17: 32658
sintering of, design of continuous furnace for, 17: 32550
sintering of, effects of controlled grain growth on, 17: 32635
sintering of, factors affecting and methods of, 17: 32544
solution in aluminum silicate glasses, 17: 32506
thermal conductivity at 100 to 1300°C, 17: 33323(R) (ORNL-3445(p.199-217))
$Al_2O_3$–$UO_2$, fabrication, properties, and radiation stability of, 17: 33262
BeO–$ThO_2$–$UO_2$, non-uniform shrinkage in sintering of, 17: 32582
BeO–$UO_2$, fabrication, properties, and radiation stability of, 17: 33262
BeO–$UO_2$, thermal conductivity and expansion of sintered, 17: 32585
$Eu_2O_3$–$UO_2$, phase studies, 17: 32572 (NP-13003)
MgO–$UO_2$, fabrication, properties, and radiation stability of, 17: 33262
$PuO_2$–$UO_2$, radiation effects on stainless-steel-clad, 17: 32663 (GEAP-3833)
$PuO_2$–$UO_2$, segregation effects in sintered pellets of, 17: 32604
$PuO_2$–$UO_2$, sintering behavior and stability of, in argon, carbon dioxide, and hydrogen, 17: 32634
$ThO_2$–$UO_2$, non-uniform shrinkage in sintering of, 17: 32582
$TiO_2$–$UO_2$, preparation of, at high temperatures, 17: 32656
$TiO_2$–$UO_2$, reactions in, at high temperatures, 17: 32656
**URANIUM(IV-VI) OXIDES**
cost forecast, 17: 32186
electric conductivity at 50 to 850°C and 150 to $10^{-3}$ mm of mercury, 17: 32562 (AEET/CD/13)
separation from acidic solutions, process for, 17: 32189(P)
use of, for preparation of uranium di- and monocarbides, 17: 32133
**URANIUM(VI) OXIDES**
bibliography on crystal structure and composition of, 17: 32049 (VDIT-77)
**URANIUM PEROXIDES**
bibliography on crystal structure and composition of, 17: 32049 (VDIT-77)
**URANIUM RESERVES**
cost forecast, 17: 32186
**URANIUM SILICATES**
spectra of, infrared, 17: 32739
**URANIUM SYSTEMS**

neutron bucklings for, critical, 17: 31794(R) (BNL-782(p.1-17))
C–Mo–U, phase studies on arc-melted, pressure-sintered, and vacuum-annealed, 17: 32616
C–Ni–U, phase studies, 17: 32637
C–N–U, thermodynamics of formation of $UC_{1-x}N_x$ in, 17: 32132
C–O–U, fabrication and properties of sintered, 17: 32486(R) (NCSC-2663-13)
C–O–U, phase studies, 17: 32486(R) (NCSC-2663-13)
C–O–U, reactions with nitrogen, 17: 32486(R) (NCSC-2663-13)
C–O–U, thermodynamics of formation of $UC_{1-x}O_x$ in, 17: 32132

**URANYL ACETATES**
benzilic acid–uranyl acetate–water, coordination compounds in, 17: 32085

**URANYL IONS**
coördination structure of, 17: 32093

**URANYL NITRATES**
precipitation of ammonium uranous fluoride from solutions of, kinetics of, 17: 32187

**URINE**
analysis for radium by sorbe-mulsion method, 17: 32013
radiation effects on riboflavin content of, therapeutic, 17: 31907

**UTERUS**
radiotherapy of cervical cancer of, effects on leukocyte count of peripheral blood, 17: 31906

## V

**VACUUM GAGES**
description of radiometric, using tritium source, 17: 32325
design and theory of ion, 17: 32385
design of modified Bayard-Alpert, with reduced x-ray limit, 17: 32366

**VACUUM SYSTEMS**
development at ORNL, 17: 33159(R) (ORNL-3472(p.107-18))

**VACUUM VALVES**
design of bakable ultrahigh, 17: 32844(R) (ARF-A218-12)

**VALLECITOS BOILING WATER REACTOR**
fuel element burnup in, 17: 33240(R) (GEAP-4303)

**VALLECITOS SUPERHEAT REACTOR**
development of, Dec. 1962–Feb. 1963, 17: 33309(R) (GEAP-4200)
development of, Mar.–May 1963, 17: 33310(R) (GEAP-4277)

**VALVES**
design and testing for reactor primary coolant systems, 17: 32227

**VAN ALLEN RADIATION BELTS**
deformation of outer, by ring current, 17: 32878
electric ring currents in, guiding-center approximation for, 17: 32863
electron flux and decay of artificial, following high-altitude nuclear explosion, 17: 32860
electron losses in, due to whistlers, 17: 32889
geomagnetic field deformations in, during magnetic storms, 17: 32864
radio wave propagation in, by particle-plasma interactions, 17: 32868

**VAN DE GRAAFF ACCELERATORS**
auxiliary equipment for ORNL 5- or 5.5-Mev, engineering drawings for, 17: 33139
charging characteristics of, 17: 33134
description and applications of 12-Mev tandem, 17: 33125
instrumentation systems for, development of transistorized, 17: 32347
use as neutron source for activation analysis, 17: 32009

**VANADIUM**
abundance in 3 Centauri A, 17: 32851
alloying effects on mechanical properties of aluminum alloys, 17: 32608
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)
separation from aliphatic alcohol-nitric acid solutions by anion exchange, 17: 32194(R) (TID-19068)

**VANADIUM ALLOYS**
Nb–V, creep and tensile properties, 17: 32568 (CONF-53-5)
Nb–V, machinability, properties, weldability, and workability of, 17: 32581
V–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519

**VANADIUM CARBIDES**
thermal decomposition, 17: 32036 (CONF-40-2)

**VANADIUM ELECTRODES**
potential of, effects of deuterium on, 17: 31989

**VANADIUM ISOTOPES V-48**
decay scheme, 17: 33056

**VANADIUM ISOTOPES V-51**
neutron reactions (n,nα) with, cross section for, 17: 31797(R) (BNL-782(p.51-9))

**VAPOR PRESSURE**
measurement in solid materials using a tracer technique, 17: 32050(T) (AEC-tr-5911)
measurement of very low, of organic materials, method and apparatus for, 17: 32391(P)

**VESSELS**
design for underwater storage of strategic materials; 17: 32229(P)

**VIRIAL COEFFICIENTS**
estimation of sixth, for hard-sphere gas, 17: 32778
of helium at high temperatures, quantum corrections to, 17: 32773

**VIRUSES**
deuterium oxide effects on replication, 17: 31837

**VITAMIN $B_2$**
radiation effects on urine content of, 17: 31907

**VITAMIN $B_{12}$**
effects of, on radiation effects on blood cells in chicks, 17: 31954

## W

**WASTE DISPOSAL**
after incorporation of radioisotopes in glass blocks, 17: 33404
fixation, by phosphate glass for, 17: 31795(R) (BNL-782(p.18-43))
fixation of fission products in ceramic microspheres for, 17: 32327
heat release from buried wastes, 17: 33407
incorporation of radioisotopes in glass, 17: 33405
of high-level wastes, 17: 33398
of highly radioactive solutions, 17: 33401
solidification of waste solutions, 17: 33406
survey, of Bogue Sound area, North Carolina, 17: 31817(R) (TID-19122)
survey of methods, 17: 33399

**WASTE PROCESSING**
by ion exchange for cerium removal, 17: 33396 (HW-SA-2920)
calcination, 17: 33403
calcination in molten sulfur, 17: 33402
calcination, shielding calculations for pot, 17: 33397 (ORNL-TM-595)
design of spray calciner, 17: 33411(P)
developments in, 17: 31795(R) (BNL-782(p.18-43))
fractionization and packaging technology in, development of, 17: 33395 (HW-SA-2786)
incorporation of radioisotopes in glass blocks, 17: 33404
incorporation of radioisotopes in glass, 17: 33405
ion exchange separation of $Sr^{90}$ and $Cs^{137}$, 17: 33408
of high-level wastes, 17: 33398
of nitric acid solutions, 17: 33400
solidification of waste solutions, 17: 33406
survey of methods, 17: 33399
treatment and packaging of solid wastes, 17: 33410

**WASTE SOLUTIONS**
analysis for radioisotopes, development of methane flow counter for, 17: 32019

**WATER**
analysis for heavy water, infrared, 17: 32006
analysis for radium by sorbe-mulsion method, 17: 32013
analysis for thorium and uranium in solutions of, by beta absorption, 17: 32014
analysis of, for deuterium by measurement of variation of vanadium electrode potential, 17: 31989
boiling of, acoustic noise production in nucleate, 17: 32251 (TRG-Report-549)
determination in materials, activation, 17: 32017
determination in sand by neutron absorption, 17: 32018
electron slowing-down spectra in, 17: 32826
environmental exposure to radium in, 17: 32314
flow of, bubble motion in turbulent, 17: 32250 (TID-19224)
free energy of formation at 1100°F, 17: 32571(R) (MSAR-63-105)
hydrogen ion dissociation in, hydrogen ion production in, 17: 33155(R)

(ORNL-3472(p.56-69))
iodine-131 deposition from, in thyroid gland, 17: 31849
neutron diffusion in, for various scattering laws, 17: 32972 (CONF-11-7)
neutron diffusion in, as function of temperature, 17: 32976
neutron spectrum in, energy exchange kernel calculations of, 17: 32970 (CONF-11-5)
nuclear magnetic resonance relaxation in silica gel sorbed, temperature dependence of, 17: 32134
radiosensitivity effects on seeds, 17: 31869
radiosensitivity effects on plants, 17: 31951
separation from air and steam, development of centrifugal separators for, 17: 32206(R) (ACNP-63021)
shielding properties of, 17: 33256
solvent effects on radioinduced graft polymerization of cotton cellulose and rayon on polystyrene, 17: 31808
solvent properties for scandium nitrates, 17: 32115
steam-water, heat transfer of, in round vertical tubes, 17: 32244 (EURAEC-637)
steam–water, heat transfer to, flowing in round vertical tubes with non-uniform axial power distribution, 17: 32245 (EURAEC-671)
steam-water, void fraction measurements in, by gamma attenuation techniques, 17: 32241(R) (ACNP-63020)
thermal neutron diffusion parameters in, poisoned with boron or cadmium, 17: 32975
benzilic acid–uranyl acetate–water, coordination compounds in, 17: 32085
steam–water, effects of geometrical factors on dryout of flowing, 17: 32260

**WATER-*d***
deuteron two-quantum transitions in, 17: 32765

**WATER-*$d_2$***
corrosive effects on Type 304 stainless steel, 17: 32516 (DPSPU-62-30-26)
determination in water, infrared, 17: 32006
deuteron-deuteron interactions on solid, neutron yield, 17: 32768
deuteron two-quantum transitions in, 17: 32765
effects on replication of virus, 17: 31837
heat conductivity of gaseous, at 100 to 500°C, 17: 32076
production of, economics and performance of processes for, 17: 32136
specific volume measurements at 275 to 425°C and 50 to 34 kg/cm², 17: 32060
thermodynamic properties of, computer program for calculating, 17: 32038 (CVNA-129)

**WATER-*t***
tritiation effects on benzene and pyridine derivatives in ammonium chloride, 17: 32142

**WATER MODERATED REACTORS**
fuel element burnup in, evaluation of plutonium recycle in, 17: 33240(R) (GEAP-4303)
moderator flow-control device for, 17: 33293(P)

**WEAR**
measurement between bearing materials, survey of, 17: 32208(R) (GDC-63-140)
measurement in cylinders and piston rings, tracer techniques for, 17: 32226
measurement of, engineering drawings of system using tracer techniques for, 17: 32380

**WELDED JOINTS**
testing of steel tube, regulations for radiation protection in x-ray, 17: 32307

**WELDING**
bibliography on effects of weld-pool agitation on properties and characteristics of welds, 17: 32533 (AD-409795)
electron-beam, of refractory metals in ionizer fabrication, 17: 32557
equipment and techniques for resistance seam-, of stainless steel sheaths, 17: 32549
specifications for, of stainless steel for structural quality welds for mildly corrosive nonradioactive service, 17: 32540 (TID-19161)
techniques of, in USSR, 17: 32541(T) (FTD-TT-62-1677)

**WELDS**
bibliography on effects of weld-pool agitation on properties and characteristics of, 17: 32533 (AD-409795)

**WINDOWS**
design for shielded enclosures, 17: 32235(P)

**WINDSCALE ADVANCED GAS COOLED REACTOR**
commissioning measurements, 17: 33346

**WOOD**
radioinduced graft polymerization of polystyrene to cellulose in red pine sapwood, 17: 31807
shielding properties of, 17: 33256

**WOUNDS**
plutonium-contaminated puncture, treatment, monitorings, and decontamination, 17: 31962 (DPSPU-63-30-5)

# X

**X RADIATION**
biological dosimetry, based on percentage of chromosomal aberrations, 17: 31897
biological effects of localized exposure to, on mammals, 17: 31883
biological effects on monocellular organisms, 17: 31890
biological effects on oocytes in rats, 17: 31913
chromosome aberrations induced by, in normal and tumorous cells, effects on cell viability, 17: 31897
chromosome healing following, in mice, 17: 31958
dosage to bones, measurement by calorimetry, 17: 32305
effects of, on blood cells in chicks, effects of folic acid, tetracycline, and vitamin $B_{12}$ on, 17: 31954
effects on absorption of labeled sodium iodide by rat skin, 17: 31957
effects on amino acid incorporation into mouse cell nuclei of, 17: 31887
effects on behavior, in dogs, 17: 31863(R) (UCD-107(p.74-85))
effects on biological life of injected fibrinogen, whole-body exposure, 17: 31916
effects on chromosome fragmentation, 17: 31935
effects on cytochromoxidase and succinic dehydrogenase activity in liver, nervous system, and skeleton in rabbits, fractionated, 17: 31979
effects on desoxyribonucleic acid in *Escherichia freundii*, reaction mechanisms, 17: 31899
effects on desoxyribonucleic acid, 17: 31922
effects on DNA, nucleoproteins, and RNA content in organs and tissues in chickens, 17: 31955
effects on dominance-submission patterns, in female dogs, 17: 31864(R) (UCD-107(p.86-97))
effects on enzymes in *E. coli*, 17: 31960
effects on eyes, delayed, 17: 31861(R) (UCD-107(p.44-9))
effects on immune response, 17: 31914
effects on immune reactions to transplanted tumors, 17: 31915
effects on induction of mammary tumors, in dogs, 17: 31860(R) (UCD-107(p.30-43))
effects on inhibition of glycolysis of Ehrlich ascites carcinoma, labile phase of, 17: 31959
effects on metabolism of proteins in lymph tissue, tracer study of, 17: 31932
effects on mouse blood formation, 17: 31941
effects on muscles in mice, protective effects of cysteamine against, 17: 31967
effects on mutation rate in Drosophila sperm, 17: 31895
effects on occurrence frequency of mutations in Drosophila, 17: 31936
effects on polymerase–DNA in *E. coli*, 17: 31832
effects on reaction to injected dyes in rabbits, whole-body exposure, 17: 31924
effects on reproduction, in dogs, 17: 31865(R) (UCD-107(p.98-111))
effects on sensitivity to toxins, of mice, 17: 31921
effects on toxic effects of cysteamine, in mice, 17: 31898
effects on work capacity and life span of dogs, delayed, 17: 31857(R) (UCD-107)
emission by plasma, 17: 33153(R) (ORNL-3472(p.24-49))
free radicals induced by, in liver and spleen lipids in rats, 17: 31927
genetic effects in the moth Ephestia, 17: 31856(R) (TID-19166)
genetic effects of exposure for 20 consecutive generations, in mice, 17: 31853 (LADC-5618)
genetic effects on seed, environmental factors in, 17: 31869

histological effects on gonads of mice, 17: 31891
inactivation of aldolase induced by, 17: 31961
lethal effects, effects of botulinum toxin in mice, 17: 31901
mutagenic effects in spermatogenesis of Drosophila, 17: 31892
pathological effects on ovaries, delayed, 17: 31866(R) (UCD-107 (p.112-28))
pathological effects in dogs, delayed, 17: 31867(R) (UCD-107(p.129-274))
pathological effects on arterial wall of hypercholesterolaemic rabbits, 17: 31900
pathological effects, long-term in dogs, 17: 31859(R) (UCD-107(p.13-29))
sensitivity of mitotic stages to, in Tradescantia microspores, 17: 31937
yields from light elements, K-, 17: 32789

**X-RAY BEAMS**
intensity measurements using thermoluminescent dosimeters, 17: 32402(R) (TID-19112)
production by electron linear accelerators, parameters for, 17: 33135
skin surface ionization reactions, 17: 31871

**X-RAY-DIFFRACTION ANALYSIS**
of mosaic crystals, secondary extinction coefficient for, 17: 32829

**X-RAY EQUIPMENT**
development of optic glass fibers for fluoroscopy, 17: 31822
dose measurements in vicinity of dental x-ray unit, 17: 32308

**X-RAY SHIELDING**
requirements of, in reference to electron-beam therapy, 17: 31824

**X-RAY SPECTRA**
satellites and nondiagram lines in emission, relations between, 17: 32777

**XENON**
fluorination of, radiation-catalyzed, 17: 31795(R) (BNL-782(p.18-43))

**XENON FLUORIDES**
Mössbauer effect in, 17: 32089
preparation of, review of, 17: 32051(T) (AEC-tr-5920)

**XENON ISOTOPES Xe-125**
use in studies of anodic oxidation of metal foils, 17: 32532

**XENON ISOTOPES Xe-129**
Mössbauer effect in compounds of, 17: 32089

**XENON ISOTOPES Xe-131**
separation from xenon-136 using thermal diffusion columns, method for, 17: 32469

**XENON ISOTOPES Xe-133**
diffusion from irradiated uranium dioxide powders and spheroids, 17: 32563 (AERE-R-4347)
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
range in tungsten at kev energies, 17: 32747
release from reactor fuel spheres, 17: 33321(R) (ORNL-3445(p.111-37))
release from uranium dioxide crystals, 17: 33320(R) (ORNL-3445(p.63-108))

**XENON ISOTOPES Xe-134**
neutron activation cross section, 17: 32398 (CEA-2215)

**XENON ISOTOPES Xe-135**
diffusion of, from irradiated uranium carbide–zirconium carbide, 17: 33272
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273
release from uranium dioxide crystals, 17: 33320(R) (ORNL-3445(p.63-108))

**XENON ISOTOPES Xe-136**
separation from xenon-131 using thermal diffusion columns, method for, 17: 32469

**XENON ISOTOPES Xe-140**
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273

**XENON ISOTOPES Xe-141**
diffusion of, from impregnated graphite shells of fuel elements, 17: 33273

**XYLENE**
radiolysis of, hydrocarbon and hydrogen yields from, 17: 31796(R) (BNL-782(p.44-50))

# Y

**YANKEE POWER REACTOR**
core evaluation program, 17: 33361
operating and refueling experience through February 1963, 17: 33355
shielding and radiation levels, 17: 33281

**YEASTS**
mutations for the isoleucine locus in, suppressor, 17: 31821

**YTTERBIUM**
determination in presence of other rare earths, spectrophotometric, 17: 32002
solubility in bismuth, 17: 31798(R) (BNL-782(p.60-91))

**YTTERBIUM BORATES**
$LaBO_3$–$YbBO_3$, structural polymorphism of, 17: 32124

**YTTERBIUM BORIDES**
nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083

**YTTERBIUM CHLORIDES**
vapor pressure, 17: 32118

**YTTERBIUM COMPLEXES**
with dibutyl phosphate solubility in dialkyl phosphoric acids in benzene at 25°, 17: 32148
with octyl phosphate, solubility in dialkyl phosphoric acids in benzene at 25°, 17: 32148

**YTTERBIUM ISOTOPES Yb-170**
energy levels of, rotational excitation of first-excited, 17: 33015

**YTTERBIUM ISOTOPES Yb-177**
decay, 17: 32724(R) (PR-P-57(p.21-36))

**YTTERBIUM NITRIDES**
properties of, electric and magnetic, 17: 32081

**YTTERBIUM SELENIDES**
crystal structure, 17: 32125

**YTTERBIUM SULFIDES**
electron structure of mono-, electric conductivity and magnetic susceptibility from, 17: 32082
properties of, electric and magnetic, 17: 32081

**YTTERBIUM TELLURIDES**
crystal structure, 17: 32125

**YTTRIUM**
alloying effects on mechanical properties of aluminum alloys, 17: 32608
electrochemical properties in phosphoric acid, 17: 32034 (CONF-20-22)
properties of, chemical and physical, 17: 32648
separation from titanium by cation exchange chromatography, 17: 32054

**YTTRIUM ALLOYS**
properties of, chemical and physical, 17: 32648

**YTTRIUM BORATES**
$LaBO_3$–$YBO_3$, structural polymorphism of, 17: 32124

**YTTRIUM BORIDES**
nuclear magnetic resonance of boron-11 in hexa-, Knight shifts in, 17: 32083

**YTTRIUM CHROMATES**
preparation and properties, 17: 32105

**YTTRIUM ISOTOPES Y-87**
production in alpha reactions with rubidium, 17: 31797(R) (BNL-782 (p.51-9))

**YTTRIUM ISOTOPES Y-89**
neutron inelastic scattering on, optical model for cross sections of, 17: 33048
proton reactions (p,n) on, cross sections for, 17: 33072

**YTTRIUM NITRIDES**
electric and optical properties, 17: 32652

**YTTRIUM OXIDES**
additive effects on hardness of zirconia to 725°C, 17: 32484(R) (GEAP-4284)
$Y_2O_3$–$ZrO_2$, phase studies, 17: 32653

# Z

**ZINC**
determination in gallium arsenide, activation, 17: 32004
determination in tissue, after neutron activation, 17: 31813 (AERE-R-4309)

effects of, on shielding properties of lead, 17: 33256
ion exchange with aluminum, copper, and zinc on Dowex 50W resin, rate of, 17: 32053
mass spectrum of secondary ions from, 17: 32389
metabolism in domestic animals, tracer study, 17: 31816(R) (ORO-605)
radiation effects on plastic deformation of, 17: 32684
radiation effects on properties of, neutron, 17: 32694
separation from bismuth by ion exchange, 17: 32195(T) (KFK-tr-130)
separation from titanium by cation exchange chromatography, 17: 32054

**ZINC ALLOYS**
Al–Mg–Zn, effects of polarization on stress corrosion of, 17: 32530
Cu–Mn–Zn, paramagnetism and valency in, 17: 32561 (AE-111)

**ZINC COMPLEXES**
bis-(dipivaloylmethanido)-, crystal and molecular structure, 17: 32040 (NYO-10552)

**ZINC CRYSTALS**
preparation and strain-rate testing, 17: 32575(R) (TID-19181)

**ZINC ISOTOPES**
proton reactions (p,α) at 20.5 Mev on, cross sections, 17: 33070

**ZINC ISOTOPES Zn-64**
deuteron elastic scattering by, cross sections for, 17: 33071
spectra of II, shift in ultraviolet lines of, 17: 33011

**ZINC ISOTOPES Zn-65**
positron spectra, 17: 32424

**ZINC ISOTOPES Zn-66**
spectra of II, shift in ultraviolet lines of, 17: 33011

**ZINC ISOTOPES Zn-68**
deuteron elastic scattering by, cross sections for, 17: 33071
spectra of II, shift in ultraviolet lines of, 17: 33011

**ZINC ISOTOPES Zn-70**
deuteron elastic scattering by, cross sections for, 17: 33071

**ZINC SULFIDE CRYSTALS**
luminescence excitation by electrons, positive temperature coefficients and saturation of, 17: 32833
trap properties of electroluminescent phosphors of, 17: 32834

**ZIRCALOY-2**
bursting of cladding tubes of, in loss-of-coolant accident in boiling and pressurized water reactors, 17: 32620
corrosion by oxygen and steam at 500°C, 17: 32520
corrosion by steam at 300, 400, and 500°C, 17: 32484(R) (GEAP-4284)
creep rate in fast neutron field, 17: 32697
dissolution in nitric acid solutions, electrolytic, 17: 32192(R) (DP-839)
engineering properties of tubes of, produced by vacuum powder metallurgy, 17: 32623
fabrication and properties, 17: 32484(R) (GEAP-4284)
hydridation of, effects on properties, 17: 32484(R) (GEAP-4284)
oxidation and mechanical properties, 17: 32621
physical properties and uses of, review on, 17: 32503
radiation effects on tensile properties of, fast neutron, 17: 32665 (HW-74955)
tensile properties of, effects of cold work and radiation on, 17: 32665 (HW-74955)

**ZIRCONIUM**
alloying effects on formation of macrostructure of aluminum alloys, 17: 32591
alloying effects on mechanical properties of magnesium–manganese–thorium alloys, 17: 32595
alloying effects on properties and structure of magnesium–thorium alloys, 17: 32596
book: *Special Metallurgy*. Vol. 3. *Zirconium and Its Alloys*, 17: 32512
corrosion by oxygen and steam at 500°C, 17: 32520
crystal structure of alpha, 17: 32580
determination in meteorites, rocks, and sediments, neutron activation, 17: 31986 (TID-19179)
dissolution in nitric acid solutions, electrolytic, 17: 32192(R) (DP-839)
effects on austenitic grain size in iron and steel, 17: 32627
effects on hot shortness of type 347 stainless steel, 17: 32628
oxidation in acid and base solutions, kinetics of anodic, 17: 32528
physical properties and uses of, review on, 17: 32503
preparation by electrolysis, 17: 32514(P)
radiation effects on plastic deformation of, 17: 32684
separation from uranium process solution, tracer studies of effects of temperature and residence times on, 17: 32191 (DP-818)
separation of, from bauxite by direct electrolysis and precipitation, economics of, 17: 32065
solubility in mercury, 17: 31798(R) (BNL-782(p.60-91))

**ZIRCONIUM ALLOYS**
book: *Special Metallurgy*. Vol. 3. *Zirconium and Its Alloys*, 17: 32512
corrosion by oxygen and steam at 500°C, 17: 32520
corrosion by steam at 300, 400, and 500°C, 17: 32484(R) (GEAP-4284)
fabrication and properties, 17: 32484(R) (GEAP-4284)
hydridation of, effects on properties, 17: 32484(R) (GEAP-4284)
Al–Cr–Zr, oxidation and mechanical properties, 17: 32621
Al–Fe–Zr, oxidation and mechanical properties, 17: 32621
Al–Ni–Zr, oxidation and mechanical properties, 17: 32621
Al–Zr, test casting in dies and molds, 17: 32591
Be–Ti–Zr, brazing of graphite to, 17: 32547
Be–Zr, wetting behavior of liquid, on solid beryllium, 17: 33323(R) (ORNL-3445(p.199-217))
Cr–Mo–Zr, oxidation and mechanical properties, 17: 32621
Cr–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519
Dy–Zr, magnetic properties of, 17: 32651
Er–Zr, magnetic properties of, 17: 32651
Fe–Mo–Zr, oxidation and mechanical properties, 17: 32621
Fe–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519
Ho–Mo–Zr, magnetic properties of, 17: 32651
Ho–Zr, magnetic properties of, 17: 32651
Mo–Nb–W–Zr, mechanical properties of warm-extruded and rolled, 17: 32567 (BMI-X-249)
Mo–Ni–Zr, oxidation and mechanical properties, 17: 32621
Mo–Zr, self-diffusion of molybdenum in, 17: 32593
Nb–Zr, corrosion resistance and tensile properties of welds in, 17: 32496
Nb–Zr, corrosion hydrogen embrittlement of, 17: 32525
Nb–Zr, creep and tensile properties, 17: 32568 (CONF-53-5)
Nb–Zr, effects on environment, heat treatment, and temperature on corrosion of, 17: 32524
Nb–Zr, preparation and properties of heat-treated, 17: 32626
Nb–Zr, properties as superconducting magnet, 17: 32712 (LNF-63/26)
Nb–Zr, resistance to sodium corrosion, 17: 31798(R) (BNL-782 (p.60-91))
Nb–Zr, superconducting critical fields of, 17: 32224
Sb–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519
Tb–Zr, magnetic properties of, 17: 32651
U–Zr, diffusion in gamma phase, 17: 32577(T) (AEC-tr-5931)
V–Zr, uptake of hydrogen during steam and water corrosion of, 17: 32519

**ZIRCONIUM BORIDES**
reactions with fluorine at high temperatures, kinetics of, 17: 32130

**ZIRCONIUM CARBIDES**
effects on austenitic grain size in iron and steel, 17: 32627
reactions with fluorine at high temperatures, kinetics of, 17: 32130
sintering without binder, pressure, 17: 32583
thermal decomposition, 17: 32036 (CONF-40-2)
UC–ZrC, carbon-stable regions in, 17: 32617
UC–ZrC, graphite coating of procedure for, 17: 33279
UC–ZrC, release of fission products from fuel inserts of, 17: 33272

**ZIRCONIUM COATINGS**
deposition of, on molybdenum and stainless steel from vapor of iodides, 17: 32507

**ZIRCONIUM COMPLEXES**
with triacyloxycyclopentadienyl, formation of, 17: 32144
with 2,4-pentanedione, gas chromatography of fluorinated and normal, 17: 32068

**ZIRCONIUM CRYSTALS**
preparation by zone melting at 2320 to 3800°K, 17: 32590
twinning in alpha, determination of $\{11\bar{2}1\}$, 17: 32632

**ZIRCONIUM FERROCYANIDES**
preparation and composition, 17: 32101

**ZIRCONIUM FLUORIDES**
vapor pressures, 17: 32116

**ZIRCONIUM HYDRIDES**

neutron thermalization in, 17: 32974 (GA-4328)
**ZIRCONIUM IODIDES**
deposition of zirconium coating on molybdenum and stainless steel from vapor of, 17: 32507
**ZIRCONIUM ISOTOPES Zr-90**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
neutron total cross sections for, resonances in, 17: 33005 (ORNL-TM-636)
**ZIRCONIUM ISOTOPES Zr-91**
deuteron reactions (d,p) with, cross sections and energy levels of, 17: 33066
neutron total cross sections for, resonances in, 17: 33005 (ORNL-TM-636)
**ZIRCONIUM ISOTOPES Zr-92**
neutron total cross sections for, resonances in, 17: 33005 (ORNL-TM-636)
**ZIRCONIUM ISOTOPES Zr-94**
neutron total cross sections for, resonances in, 17: 33005 (ORNL-TM-636)
**ZIRCONIUM ISOTOPES Zr-95**
determination in seaweed and sea water, spectrometric, 17: 32005
**ZIRCONIUM ISOTOPES Zr-96**
neutron total cross sections for, resonances in, 17: 33005 (ORNL-TM-636)
**ZIRCONIUM ISOTOPES Zr-97**
yields from spontaneous fission of uranium-238, 17: 33109
**ZIRCONIUM NITRIDES**
effects on austenitic grain size in iron and steel, 17: 32627
**ZIRCONIUM OXIDES**
coating of, by plasma-arc spraying, 17: 32545
effects on austenitic grain size in iron and steel, 17: 32627
effects on electrochemical properties of lithium silicate glass, 17: 32095
effects on electrochemical properties of glass, 17: 32098
hardness of doped and pure, at 20 to 725°C, 17: 32484(R) (GEAP-4284)
phase stabilization by oxide additions, 17: 32653
preparation of crystals of, by zone melting at 2320 to 3800°K, 17: 32590
preparation of hydrogen-containing, relation to metal oxide bronzes, 17: 32088
reduction by calcium carbide or calcium cyanamide, 17: 32059
separation from oxides as function of $SO_3$–$ZrO_2$ ratio, 17: 32077
CaO–MgO–$ZrO_2$, phase studies, 17: 32653
CaO–$ZrO_2$, grain growth of $Ca_{0.15}Zr_{0.85}O_{1.85}$, 17: 32135
CaO–$ZrO_2$, phase studies, 17: 32653
$CeO_2$–$ZrO_2$, phase studies, 17: 32653
MgO–$ZrO_2$, phase studies, 17: 32653
$Y_2O_3$–$ZrO_2$, phase studies, 17: 32653
**ZIRCONIUM SYSTEMS**
B–Zr, production of, by sintering at 470 to 1150°C, 17: 32497
D–Zr, phase studies, 17: 32580

# REPORT NUMBER INDEX

All reports, translations, and patents abstracted in this issue are included in this index. Each item is listed by report number; this is followed by the abstract number and a brief notation regarding public availability. The index entries show, when known, which reports are on file in the depository libraries, which reports have been published in open-literature journals (journal citation given), and which reports can be purchased (source and price). Whenever a report is identified by more than one number, cross references from secondary to primary report numbers are cited.

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| 1771 | 17-33025 | Can. J. Phys., 41: 1263-72(1963) |
| 1778 | 17-32722 | See PR-P-57 |
| 1779 | 17-32747 | Can. J. Phys., 41: 1231-44(1963) |
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| 266 | 17-32968 | See BNL-765 |
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| 816 | 17-32376 | EM |
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| 818 | 17-32378 | EM |
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| 820 | 17-32380 | EM |
| 821 | 17-32381 | EM |
| 822 | 17-32382 | EM |
| 888 | 17-32383 | EM |
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| 3 | 17-32261 | ORINS. New York, American Society of Mechanical Engineers, 1963, Preprint 63-APM-7 |
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| 14 | 17-32215 | ORINS |
| 15 | 17-33359 | ORINS |
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| 17 | 17-33355 | ORINS |
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| 38 | 17-32219 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63010 |
| 40 | 17-33192 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63012-63 |
| 41 | 17-33205 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63011 |
| 42 | 17-33203 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63013 |
| 43 | 17-33196 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, |

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| | | Preprint 63014A |
| 44 | 17-33197 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63014B |
| 48 | 17-33204 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63001-63 |
| 51 | 17-32225 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63004 |
| 53 | 17-33211 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63045-63 |
| 55 | 17-33210 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63047 |
| 56 | 17-33390 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63048-63 |
| 57 | 17-33391 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63048B |
| 58 | 17-32217 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63049-63 |
| 59 | 17-32218 | ORINS. New York, American Institute of Aeronautics and Astronautics, 1963, Preprint 63039 |
| 60 | 17-33392 | ORINS |
| **CONF-11–** | **(American Nuclear Society Meeting, Washington, D. C., November 1963)** | |
| 5 | 17-32970 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 6 | 17-32971 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 7 | 17-32972 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| **CONF-13** | **(American Physical Society Meeting, Houston, Texas, February–March 1963)** | |
| 1 | 17-32481 | ORINS. Gmelin, AED-CONF-1963-013-11 |
| **CONF-14–** | **(American Chemical Society 144th National Meeting, Los Angeles, Calif., March–April 1963)** | |
| 2 | 17-32175 | ORINS. Gmelin, AED-CONF-1963-025-7 |
| 3 | 17-33280 | ORINS. Gmelin, AED-CONF-1963-025-6 |
| 8 | 17-33396 | See HW-SA-2920 |
| 12 | 17-32123 | ORINS. Gmelin, AED-CONF-1963-025-2 |
| 16 | 17-32693 | ORINS. Gmelin, AED-CONF-1963-025-11 |
| 17 | 17-32151 | ORINS. Gmelin, AED-CONF-63-025-25 |
| 18 | 17-32130 | ORINS. Gmelin, AED-CONF-63-025-32 |
| 21 | 17-32152 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-025-29 |
| 27 | 17-32472 | ORINS. Gmelin, AED-CONF-63-025-54 |
| **CONF-15–** | **(American Power Conference, Chicago, March 1963)** | |
| 1 | 17-32203 | ORINS. Gmelin, AED-CONF-1963-023-2 |
| 3 | 17-33344 | ORINS. Gmelin, AED-CONF-1963-023-4 |
| 8 | 17-33348 | ORINS. Gmelin, AED-CONF-1963-023-9 |
| 9 | 17-33353 | ORINS. Gmelin, AED-CONF-63-023-13 |
| 10 | 17-33352 | ORINS. Gmelin, AED-CONF-63-023-14 |
| 11 | 17-33351 | ORINS. Gmelin, AED-CONF-63-023-12 |
| **CONF-16** | **(International Symposium on the Natural Radiation Environment, Houston, Texas, April 1963)** | |
| 1 | 17-31984 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-1963-033-1 |
| 8 | 17-31829 | ORINS. Gmelin, AED-CONF-1963-033-4 |
| 9 | 17-32280 | ORINS. Gmelin, AED-CONF-63-033-13 |
| 10 | 17-32312 | ORINS. Gmelin, AED-CONF-63-033-12 |
| 11 | 17-32459 | ORINS. Gmelin, AED-CONF-63-033-11 |
| 12 | 17-32314 | ORINS. Gmelin, AED-CONF-63-033-10 |

| Report No. | Abstract No. | Availability |
|---|---|---|
| **CONF-17–** | **(Oak Ridge Radioisotopes Conference, Applications in Physical Science and Engineering, Gatlinburg, Tenn., April 1963)** | |
| 1 | 17-32386 | ORINS. Gmelin, AED-CONF-1963-026-1 |
| 5 | 17-32327 | ORINS. Gmelin, AED-CONF-63-026-9 |
| **CONF-19–** | **(2nd International Congress of Radiation Research, Harrogate, England, August 1962)** | |
| 2 | 17-32826 | ORINS. Gmelin, AED-CONF-62-217-179 |
| 3 | 17-31960 | ORINS. Gmelin, AED-CONF-1962-217-174 |
| 4 | 17-31961 | ORINS. Gmelin, AED-CONF-62-217-184 |
| **CONF-20–** | **(3rd Rare Earth Conference, Clearwater, Fla., April 1963)** | |
| 5 | 17-32033 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-040-7 |
| 8 | 17-32124 | ORINS. Gmelin, AED-CONF-63-040-12 |
| 11 | 17-32125 | ORINS. Gmelin, AED-CONF-63-040-4 |
| 13 | 17-32651 | ORINS. Gmelin, AED-CONF-63-040-16 |
| 22 | 17-32034 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-040-27 |
| 23 | 17-32654 | ORINS. Gmelin, AED-CONF-63-040-29 |
| 24 | 17-32652 | ORINS. Gmelin, AED-CONF-63-040-30 |
| 25 | 17-32819 | ORINS. Gmelin, AED-CONF-63-040-28 |
| 26 | 17-32818 | ORINS. Gmelin, AED-CONF-63-040-26 |
| 28 | 17-32035 | Dep.(mc); $2.60(fs), $0.86(mf) OTS; Gmelin, AED-CONF-63-040-23 |
| **CONF-21–** | **(National Association of Corrosion Engineers Meeting, New York, March 1963)** | |
| 2 | 17-32531 | ORINS. Gmelin, AED-CONF-1963-019-4 |
| **CONF-22–** | **(American Physical Society Meeting, New York, January 1963)** | |
| 3 | 17-33096 | ORINS. Gmelin, AED-CONF-1963-007-82 |
| 9 | 17-33104 | ORINS. Gmelin, AED-CONF-63-007-85 |
| 10 | 17-32993 | See BNL-6955 |
| 11 | 17-33103 | ORINS. Gmelin, AED-CONF-63-007-86 |
| 14 | 17-33092 | ORINS. Gmelin, AED-CONF-1963-007-67 |
| 17 | 17-33105 | ORINS. Gmelin, AED-CONF-63-007-95 |
| 18 | 17-33107 | ORINS. Gmelin, AED-CONF-63-007-96 |
| 19 | 17-32816 | ORINS. Gmelin, AED-CONF-63-007-94 |
| **CONF-23** | **(American Physical Society Meeting, St. Louis, March 1963)** | |
| 3 | 17-32696 | ORINS. Gmelin, AED-CONF-1963-022-22 |
| 10 | 17-32692 | ORINS. Gmelin, AED-CONF-1963-022-14 |
| 13 | 17-33102 | ORINS. Gmelin, AED-CONF-1963-022-3 |
| 14 | 17-32694 | ORINS. Gmelin, AED-CONF-1963-022-2 |
| 15 | 17-33007 | See UCRL-7297 |
| 18 | 17-32659 | ORINS. Gmelin, AED-CONF-63-022-32 |
| 19 | 17-32706 | Dep.(mc); $3.60(fs), $1.13(mf) OTS; Gmelin, AED-CONF-63-022-36 |
| **CONF-24–** | **(Symposium on Engineering Aspects of Magnetohydrodynamics, Berkeley, Calif., April 1963)** | |
| 2 | 17-33194 | ORINS. Gmelin, AED-CONF-1963-030-5 |
| 3 | 17-32817 | ORINS. Gmelin, AED-CONF-1963-030-3 |
| 4 | 17-32388 | ORINS. Gmelin, AED-CONF-1963-030-1 |
| 5 | 17-33193 | ORINS. Gmelin, AED-CONF-63-030-10 |
| 7 | 17-33216 | ORINS. Gmelin, AED-CONF-63-030-8 |
| 10 | 17-32824 | ORINS. Gmelin, AED-CONF-63-030-11 |
| 13 | 17-33212 | ORINS. Gmelin, AED-CONF-63-030-15 |
| 14 | 17-33209 | ORINS. Gmelin, AED-CONF-63-030-16 |
| 15 | 17-33208 | ORINS. Gmelin, AED-CONF-63-030-17 |
| 16 | 17-33219 | ORINS. Gmelin, AED-CONF-63-030-13 |
| **CONF-26–** | **(Optical Society of America Meeting, Jacksonville, Fla., March 1963)** | |
| 1 | 17-32397 | See BNL-6848 |
| 3 | 17-32332 | See BNL-6878 |
| 4 | 17-32729 | See SCR-636 |

| Report No. | Abstract No. | Availability |
|---|---|---|
| **CONF-28–** | **(Second International Congress on Metallic Corrosion, New York, New York, March 1963)** | |
| 2 | 17-32530 | ORINS. Gmelin, AED-CONF-63-018-16 |
| 3 | 17-32529 | ORINS. Gmelin, AED-CONF-63-018-14 |
| 5 | 17-32516 | See DPSPU-62-30-26 |
| **CONF-31–** | **(American Crystallographic Association Annual Meeting, Villanova, Penna., June 1962)** | |
| 1 | 17-32622 | Phys. Rev., 129: 2008-18(1963) |
| **CONF-35–** | **(American Physical Society, Cambridge, Mass., March 1963)** | |
| 2 | 17-32650 | ORINS. Gmelin, AED-CONF-1963-024-1 |
| **CONF-37–** | **(American Chemical Society Southwest Regional Meeting, Dallas, December 1962)** | |
| 2 | 17-32134 | ORINS. Gmelin, AED-CONF-1962-264-2 |
| 4 | 17-31980 | $2.60(fs), $1.04(mf) OTS |
| **CONF-38–** | **(4th Annual Meeting, American Physical Society, Atlantic City, N. J., Nov. 28–Dec. 1, 1962)** | |
| 3 | 17-33145 | See MATT-157 |
| 6 | 17-33195 | ORINS. Gmelin, AED-CONF-62-251-51 |
| 7 | 17-33200 | ORINS. Gmelin, AED-CONF-62-251-48 |
| **CONF-39–** | **(American Nuclear Society Meeting, Salt Lake City, Utah, June 1963)** | |
| 3 | 17-33346 | ORINS. Gmelin, AED-CONF-63-060-14 |
| 4 | 17-33345 | ORINS. Gmelin, AED-CONF-63-060-13 |
| 5 | 17-33225 | ORINS. Gmelin, AED-CONF-63-060-12 |
| 6 | 17-32026 | ORINS. Gmelin, AED-CONF-63-060-50 |
| 7 | 17-32460 | ORINS. Gmelin, AED-CONF-63-060-48 |
| 9 | 17-33224 | ORINS. Gmelin, AED-CONF-63-060-42 |
| 10 | 17-32179 | ORINS. Gmelin, AED-CONF-63-060-4 |
| 13 | 17-32836 | ORINS. Gmelin, AED-CONF-63-060-33 |
| 15 | 17-33354 | ORINS. Gmelin, AED-CONF-63-060-25 |
| 19 | 17-32988 | ORINS. Gmelin, AED-CONF-63-060-9 |
| 21 | 17-32895 | See HW-SA-2999 |
| 23 | 17-32399 | See HW-SA-2932 |
| 24 | 17-32974 | See GA-4328 |
| 25 | 17-33245 | See WAPD-T-1582 |
| 26 | 17-32969 | See BNL-6949 |
| 28 | 17-32537 | See HW-SA-2904 |
| 29 | 17-33363 | See HW-SA-2891(Rev.) |
| 33 | 17-33304 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-060-19 |
| 37 | 17-32994 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-060-21 |
| 46 | 17-32973 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-060-49 |
| 47 | 17-32894 | Dep.(mc); $2.60(fs), $0.86(mf) OTS; Gmelin, AED-CONF-63-060-15 |
| 49 | 17-33305 | Dep.(mc); $4.60(fs), $1.52(mf) OTS; Gmelin, AED-CONF-63-060-27 |
| 53 | 17-32333 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-060-28 |
| 55 | 17-32919 | See WAPD-T-1579 |
| **CONF-40–** | **(Sixth Annual Conference on Vacuum Metallurgy, June 1963)** | |
| 2 | 17-32036 | Dep.(mc); $3.60(fs), $1.22(mf) OTS; Gmelin, AED-CONF-63-084-1 |
| **CONF-46–** | **(American Physical Society Meeting, Washington, D. C., April 1963)** | |
| 8 | 17-33006 | See UCRL-7192 |
| 12 | 17-32830 | ORINS. Gmelin, AED-CONF-63-048-28 |
| 14 | 17-33095 | ORINS. Gmelin, AED-CONF-63-048-22 |
| 19 | 17-33086 | ORINS. Gmelin, AED-CONF-63-048-75 |
| 20 | 17-32820 | ORINS. Gmelin, AED-CONF-63-048-77 |
| 21 | 17-32893 | ORINS. Gmelin, AED-CONF-63-048-79 |
| 24 | 17-32883 | ORINS. Gmelin, AED-CONF-63-048-69 |
| 26 | 17-33089 | ORINS. Gmelin, AED-CONF-63-048-72 |
| 27 | 17-32704 | See BNL-6916 |
| 30 | 17-33147 | See MATT-198 |
| 31 | 17-33097 | ORINS. Gmelin, AED-CONF-63-048-56 |
| 32 | 17-33099 | ORINS. Gmelin, AED-CONF-63-048-57 |
| 33 | 17-33140 | ORINS. Gmelin, AED-CONF-63-048-59 |
| 34 | 17-32403 | See UCRL-7169 |
| 35 | 17-33218 | ORINS. Gmelin, AED-CONF-63-048-67 |
| 36 | 17-33146 | See MATT-169 |
| 42 | 17-33217 | ORINS. Gmelin, AED-CONF-63-048-66 |
| 43 | 17-32707 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-048-52 |
| 44 | 17-32995 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-048-51 |
| 47 | 17-32897 | See BNL-6962 |
| 50 | 17-32838 | ORINS. Gmelin, AED-CONF-63-048-49 |
| 51 | 17-33091 | ORINS. Gmelin, AED-CONF-63-048-48 |
| 52 | 17-33101 | ORINS. Gmelin, AED-CONF-63-048-47 |
| 53 | 17-33100 | ORINS. Gmelin, AED-CONF-63-048-46 |
| 55 | 17-33090 | ORINS. Gmelin, AED-CONF-63-048-41 |
| 56 | 17-33106 | ORINS. Gmelin, AED-CONF-63-048-40 |
| 57 | 17-32965 | ORINS. Gmelin, AED-CONF-63-048-38 |
| 58 | 17-32457 | ORINS. Gmelin, AED-CONF-63-048-37 |
| 59 | 17-32967 | ORINS. Gmelin, AED-CONF-63-048-36 |
| 60 | 17-32966 | ORINS. Gmelin, AED-CONF-63-048-35 |
| 61 | 17-32385 | ORINS. Gmelin, AED-CONF-63-048-34 |
| 63 | 17-31812 | ORINS. Gmelin, AED-CONF-63-048-87 |
| 64 | 17-32839 | ORINS. Gmelin, AED-CONF-63-048-86 |
| 66 | 17-32907 | See NYO-10271 |
| 67 | 17-33199 | ORINS. Gmelin, AED-CONF-63-048-14 |
| 72 | 17-33198 | ORINS. Gmelin, AED-CONF-63-048-2 |
| 73 | 17-33093 | ORINS. Gmelin, AED-CONF-63-048-1 |
| 78 | 17-32996 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-048-90 |
| 79 | 17-32997 | Dep.(mc); $4.60(fs), $1.58(mf) OTS; Gmelin, AED-CONF-63-048-88 |
| 80 | 17-32899 | Dep.(mc); $2.60(fs), $0.95(mf) OTS; Gmelin, AED-CONF-63-048-81 |
| **CONF-48–** | **(Conference on Analytical Chemistry and Applied Spectroscopy, Pittsburgh, March 1963)** | |
| 2 | 17-32028 | ORINS. Gmelin, AED-CONF-1963-014-7 |
| **CONF-49–** | **(International Symposium on Unit Process in Hydrometallurgy, Dallas, February 1963)** | |
| 2 | 17-32187 | ORINS. Gmelin, AED-CONF-63-012-9 |
| **CONF-50–** | **(American Ceramic Society Annual Meeting, Pittsburgh, April–May 1963)** | |
| 3 | 17-32534 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-046-6 |
| 10 | 17-32653 | ORINS. Gmelin, AED-CONF-63-046-10 |
| 11 | 17-32135 | ORINS. Gmelin, AED-CONF-63-046-6 |
| 14 | 17-32037 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-046-15 |
| 15 | 17-32535 | Dep.(mc); $2.60(fs), $0.98(mf) OTS; Gmelin, AED-CONF-63-046-14 |
| **CONF-51–** | **(American Public Power Assn. 20th Annual Convention, Cleveland, April–May 1963)** | |
| 1 | 17-33349 | ORINS. Gmelin, AED-CONF-63-047-2 |
| **CONF-52–** | **(2nd International Conference on Nuclidic Masses, Vienna, July 1963)** | |
| 3 | 17-32998 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |
| **CONF-53–** | **(1962 World Metal Show, New York, New York, Oct. 29–Nov. 2, 1962)** | |
| 5 | 17-32568 | Dep.(mc); $2.60(fs), $0.86(mf) OTS |

| Report No. | Abstract No. | Availability |
|---|---|---|
| **CONF-54–** | **(4th Omnibus Conference on Experimental Aspects of Nuclear Magnetic Resonance Spectroscopy, Pittsburgh, February–March 1963)** | |
| 1 | 17-32569 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-1963-036-1 |
| **CONF-55–** | **(Symposium on Trace Gases and Natural and Artificial Radioactivity in the Atmosphere, Utrecht, August 1962)** | |
| 1 | 17-32281 | ORINS. Gmelin, AED-CONF-1962-142-23 |
| **CONF-57–** | **(Electron Beam Symposium, Boston, March 1963)** | |
| 1 | 17-32821 | ORINS. Gmelin, AED-CONF-1963-031-2 |
| 2 | 17-32695 | ORINS. Gmelin, AED-CONF-63-031-8 |
| 4 | 17-32557 | ORINS. Gmelin, AED-CONF-63-031-4 |
| 5 | 17-32822 | ORINS. Gmelin, AED-CONF-63-031-10 |
| **CONF-58–** | **(Institute of Electrical and Electronics Engineers International Convention, New York, March 1963)** | |
| 4 | 17-32334 | Dep.(mc); $2.60(fs), $0.86(mf) OTS; Gmelin, AED-CONF-63-034-3 |
| **CONF-62–** | **(3rd Conference on Reactions Between Complex Nuclei, Asilomar, Calif., April 1963)** | |
| 3 | 17-33088 | ORINS. Gmelin, AED-CONF-63-054-9 |
| 4 | 17-33087 | ORINS. Gmelin, AED-CONF-63-054-5 |
| 5 | 17-33094 | ORINS. Gmelin, AED-CONF-63-054-3 |
| 7 | 17-32999 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-054-4 |
| 10 | 17-33098 | ORINS. Gmelin, AED-CONF-63-054-10 |
| **CONF-63–** | **(American Physical Society Meeting, Seattle, August 1962)** | |
| 2 | 17-32880 | ORINS. Gmelin, AED-CONF-62-149-113 |
| **CONF-64–** | **(American Crystallographic Assn. Meeting, Cambridge, Mass., March 1963)** | |
| 2 | 17-32829 | ORINS. Gmelin, AED-CONF-63-053-3 |
| **CONF-65–** | **(Federation of American Societies for Experimental Biology Meeting, Atlantic City, N. J., April 1963)** | |
| 1 | 17-31851 | See BNL-6989 |
| 2 | 17-31839 | ORINS. Gmelin, AED-CONF-63-052-9 |
| 4 | 17-31840 | ORINS. Gmelin, AED-CONF-63-052-6 |
| 5 | 17-31841 | ORINS. Gmelin, AED-CONF-63-052-8 |
| **CONF-66–** | **(Symposium on the Biology of Radioiodine, Richland, Wash., June 1963)** | |
| 1 | 17-31848 | ORINS. Gmelin, AED-CONF-63-063-2 |
| 3 | 17-32284 | See DPSPU-63-30-26B |
| 4 | 17-31849 | ORINS. Gmelin, AED-CONF-63-063-1 |
| **CONF-67–** | **(Health Physics Society Annual Meeting, New York, New York, June 1963)** | |
| 1 | 17-33388 | ORINS. Gmelin, AED-CONF-63-049-4 |
| 2 | 17-32313 | ORINS. Gmelin, AED-CONF-63-049-3 |
| 5 | 17-32286 | See HW-76351 |
| 8 | 17-31962 | See DPSPU-63-30-5 |
| 9 | 17-32316 | ORINS. Gmelin, AED-CONF-63-049-13 |
| 10 | 17-32317 | ORINS. Gmelin, AED-CONF-63-049-16 |
| 15 | 17-33000 | Dep.(mc); $2.60(fs), $0.95(mf) OTS; Gmelin, AED-CONF-63-049-14 |
| 16 | 17-31853 | See LADC-5618 |
| 17 | 17-31815 | See LADC-5627 |
| **CONF-68–** | **(Electrochemical Society, Pittsburgh, April 1963)** | |
| 1 | 17-32458 | ORINS. Gmelin, AED-CONF-63-064-1 |
| 5 | 17-32532 | ORINS. Gmelin, AED-CONF-63-064-3 |
| **CONF-69–** | **(Conference on Operating Experience with Power Reactors, Vienna, June 1963)** | |
| 1 | 17-33340 | ORINS |
| 2 | 17-33338 | ORINS |
| 3 | 17-33343 | ORINS |
| 4 | 17-33337 | ORINS |
| 5 | 17-33341 | ORINS |
| 6 | 17-33339 | ORINS |
| 8 | 17-33342 | ORINS |
| **CONF-70–** | **(National Symposium of the Professional Technical Group on Microwave Theory and Techniques, Santa Monica, Calif., May 1963)** | |
| 2 | 17-33215 | ORINS. Gmelin, AED-CONF-63-069-2 |
| **CONF-71–** | **(Gaseous Electronics Conference, Boulder, Colo., October 1962)** | |
| 1 | 17-32882 | ORINS. Gmelin, AED-CONF-62-186-18 |
| **CONF-72–** | **(Transplutonium Element Symposium, Argonne, Ill., May 1963)** | |
| 3 | 17-32733 | See UCRL-7314(Rev.I) |
| **CONF-73–** | **(Sixth Biennial Conference on Carbon, Univ. of Pittsburgh, June 1963)** | |
| 3 | 17-32649 | ORINS. Gmelin, AED-CONF-63-061-7 |
| 4 | 17-32128 | ORINS. Gmelin, AED-CONF-63-061-10 |
| 5 | 17-32655 | ORINS. Gmelin, AED-CONF-63-061-5 |
| 6 | 17-32667 | See HW-SA-2926 |
| **CONF-74–** | **(ASTM Conference on Mass Spectrometry and Allied Topics, San Francisco, May 1963)** | |
| 1 | 17-32389 | ORINS. Gmelin, AED-CONF-63-050-13 |
| 6 | 17-32387 | ORINS. Gmelin, AED-CONF-63-050-5 |
| 8 | 17-32384 | ORINS. Gmelin, AED-CONF-63-050-15 |
| 9 | 17-33213 | ORINS. Gmelin, AED-CONF-63-050-19 |
| 10 | 17-32837 | ORINS |
| **CONF-75–** | **(Sixth International Symposium on Ionization Phenomena in Gases, Orsay, France, July 1963)** | |
| 2 | 17-33206 | ORINS |
| 3 | 17-32734 | See UCRL-7357 |
| **CONF-76–** | **(Symposium on Molecular Structure and Spectroscopy, Columbus, Ohio, June 1963)** | |
| 1 | 17-32129 | ORINS. Gmelin, AED-CONF-63-074-3 |
| 2 | 17-32823 | ORINS. Gmelin, AED-CONF-63-074-1 |
| **CONF-77–** | **(Symposium on Plasma Space Science, Washington, D. C., June 1963)** | |
| 3 | 17-32279 | ORINS. Gmelin, AED-CONF-63-051-3 |
| **CONF-78–** | **(American Physical Society Meeting, Buffalo, June 1963)** | |
| 1 | 17-33214 | ORINS. Gmelin, AED-CONF-63-090-3 |
| **CONF-79–** | **(American Inst. of Aeronautics Manned Space Lab. Conference, Los Angeles, May 1963)** | |
| 1 | 17-33389 | ORINS. Gmelin, AED-CONF-63-091-1 |
| **CONF-80–** | **(Inst. of Nuclear Materials Management Annual Meeting, Buffalo, June 1963)** | |
| 1 | 17-33269 | ORINS. Gmelin, AED-CONF-63-071-3 |
| 2 | 17-32315 | ORINS. Gmelin, AED-CONF-63-071-1 |
| **CONF-81–** | **(Conference on Basic Mechanisms in the Radiation Chemistry of Aqueous Media, Gatlinburg, Tenn., May 1963)** | |
| 1 | 17-32178 | ORINS. Gmelin, AED-CONF-63-075-3 |
| 2 | 17-32176 | ORINS. Gmelin, AED-CONF-63-075-1 |
| **CONF-82–** | **(Canadian Nuclear Association Conference on Heavy Water Reactors, Ottawa, May 1962)** | |
| 1 | 17-32697 | ORINS |
| 2 | 17-32227 | ORINS |
| 3 | 17-33347 | ORINS |

| Report No. | Abstract No. | Availability |
|---|---|---|
| 4 | 17-32326 | ORINS |
| 6 | 17-33350 | ORINS |
| **CONF-84–** | **(American Industrial Health Conference, Cincinnati, May 1963)** | |
| 1 | 17-32291 | See UCRL-7311 |
| **CONF-85–** | **(American Meteorological Society Meeting, Washington, D. C., April 1963)** | |
| 2 | 17-32881 | ORINS. Gmelin, AED-CONF-63-072-1 |
| **CONF-86–** | **(Symposium on Plasma Sheath, Bedford, Mass., April 1962)** | |
| 1 | 17-33202 | ORINS. Gmelin, AED-CONF-62-039-10 |
| **CONF-93–** | **(International Coaxial Plasma Gun Symposium, Cleveland, September 1962)** | |
| 2 | 17-33207 | ORINS |
| **CONF-96–** | **(American Nuclear Society Meeting, Nuclear Materials for Space Applications, Cincinnati, April 1963)** | |
| 2 | 17-32699 | ORINS. Gmelin, AED-CONF-63-067-3 |
| 3 | 17-32032 | See CNLM-5066 |
| 6 | 17-32513 | ORINS. Gmelin, AED-CONF-63-067-1 |
| 7 | 17-33393 | ORINS. Gmelin, AED-CONF-63-067-9 |
| **CONF-96–** | **(International Summer Meeting, Montreal, June 1963)** | |
| 1 | 17-32226 | ORINS |
| **CONF-97–** | **(Summer Meeting, Los Angeles, June 1963)** | |
| 21 | 17-33201 | ORINS. New York, American Inst. of Aeronautics and Astronautics, 1963, Preprint 63-201, $1.00 |
| **CONF-100–** | **(Meeting on Production and Maturation of Leukocytes, New York, May 1963)** | |
| 1 | 17-31852 | See BNL-7137 |
| **CONF-102–** | **(Winter Meeting of ASME, Philadelphia, Pennsylvania, November 1963)** | |
| 1 | 17-33370 | See HW-SA-3098 |
| **CONF-103–** | **(Conference on Instrument Techniques in Nuclear Pulse Analysis, Monterey, Calif., April–May 1963)** | |
| 1 | 17-32343 | See UCRL-10874 |
| **CONF-104–** | **(IAEA Symposium on Radiological Health and Safety in Nuclear Materials, Mining and Milling, Vienna, August 1963)** | |
| 1 | 17-32310 | Dep.(mc); $3.60(fs), $1.13(mf) OTS; Preprint No. SM/41-32 |
| 2 | 17-32311 | Dep.(mc); $2.60(fs), $0.95(mf) OTS; Preprint No. SM/41-33 |
| **CONF-110–** | **(Annual Meeting of the American Institute of Chemical Engineers, Houston, Texas, December 1963)** | |
| 1 | 17-32474 | See IS-698 |
| **CONF-112–** | **(National Convention on Nondestructive Testing, Los Angeles, March 1963)** | |
| 1 | 17-32262 | See HW-SA-2927 |
| **CONF-114–** | **(International Conference on High Energy Accelerators, Dubna, August 1963)** | |
| 1 | 17-33120 | See UCRL-10866 |
| 2 | 17-33119 | See UCRL-7408 |
| 3 | 17-33121 | See UCRL-10867 |
| 4 | 17-33122 | See UCRL-10868 |
| **CONF-115–** | **(Pan-American Conference on Radiochemistry, Montevideo, Uruguay, July 1963)** | |
| 1 | 17-32029 | ORINS |
| **CONF-120–** | **(Conference on New Nuclear Materials Technology, Including Non-Metallic Fuel Elements, Prague, July 1963)** | |
| 1 | 17-32126 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/16 |
| 2 | 17-32132 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/3 |
| 3 | 17-32133 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/14 |
| 4 | 17-32556 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/5 |
| 5 | 17-33278 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/7 |
| 6 | 17-32127 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/8 |
| 7 | 17-33277 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/9 |
| 8 | 17-32698 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/10 |
| 9 | 17-33276 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/13 |
| 10 | 17-33275 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/15 |
| 11 | 17-32550 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/17 |
| 12 | 17-32551 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/18 |
| 13 | 17-33274 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/25 |
| 14 | 17-33273 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/43 |
| 15 | 17-33272 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/44 |
| 16 | 17-32552 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/55 |
| 17 | 17-32658 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/56 |
| 18 | 17-32555 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/61 |
| 19 | 17-32131 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/63 |
| 20 | 17-32027 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/64 |
| 21 | 17-33271 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/65 |
| 22 | 17-32553 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/67 |
| 23 | 17-32657 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/69 |
| 24 | 17-33270 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/71 |
| 26 | 17-32554 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/68 |
| 27 | 17-32656 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/54 |
| 29 | 17-33279 | ORINS. Vienna, International Atomic Energy Agency, 1963, Preprint CN-16/1 |
| **CONF-121–** | **(International Symposium on Radiation Induced Polymerization and Graft Copolymerization, Columbus, Ohio, November 1962)** | |
| 1 | 17-32177 | ORINS. Gmelin, AED-CONF-62-233-13 |
| **CONF-122–** | **(International Conference on Nucleon Structure, Stanford Univ., June 1963)** | |
| 1 | 17-32905 | See LAL-1072 |
| 2 | 17-32918 | See UCRL-10897 |
| **CONF-124–** | **(Symposium on the Application of Advanced Technology to Coal Research, Lexington, Ky., June 1963)** | |
| 1 | 17-31985 | Dep.(mc); $4.60(fs), $1.49(mf) OTS; |

| Report No. | Abstract No. | Availability |
|---|---|---|
| | | Gmelin, AED-CONF-63-092-1 |
| 2 | 17-32320 | Dep.(mc); $2.60(fs), $0.95(mf) OTS; Gmelin, AED-CONF-63-092-2 |
| **CONF-125–** | **(Sector-Focused Cyclotron and Meson Factory Conference at CERN, Geneva, Switzerland, April 1963)** | |
| 1 | 17-33111 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 2 | 17-33112 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 3 | 17-33113 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 4 | 17-33114 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 5 | 17-33115 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **CONF-128–** | **(American Physical Society Meeting, Tallahassee, April 1963)** | |
| 1 | 17-33001 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-62-221-20 |
| **CONF-129–** | **(Heat Transfer Conference, Boston, August 1963)** | |
| 2 | 17-32260 | ORINS. New York, American Inst. of Chemical Engineers, 1963, Preprint Paper 37, $0.50 |
| **CONF-130–** | **(International Conference on Hyperfragments at St. Cergue, April 1963)** | |
| 1 | 17-32901 | See EFINS-63-32 |
| 2 | 17-32900 | See EFINS-63-29 |
| **CONF-134–** | **(Conference on Engineering in Medicine and Biology, Baltimore, November 1963)** | |
| 1 | 17-32476 | See UCRL-10927 |
| **CONF-135–** | **(International Symposium on High Temperature Technology, Asilomar, Calif., September 1963)** | |
| 1 | 17-31981 | See UCRL-10882 |
| **CONF-136–** | **(Symposium on the National Environment, Houston, Texas, April 1963)** | |
| 1 | 17-32264 | See UCRL-10636 |
| **CRDC–** | **(Canadian)** | |
| 1143 | 17-32661 | Dep.(mc); $3.00(AECL) |
| **CRFD–** | **(Canadian)** | |
| 1132 | 17-32662 | Dep.; $0.50(AECL) |
| **CVNA–** | **(Misc.)** | |
| 129 | 17-32038 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| 146(Vols.I&II) | 17-33238 | Dep.; $4.00(OTS) |
| **D–** | **(Misc.)** | |
| 1-82-0218* | 17-33142 | |
| 1-82-0229* | 17-33143 | |
| 1-82-0254* | 17-32708 | |
| 1-82-0255* | 17-33144 | |
| **DESY-A–** | **(German)** | |
| 2.99 | 17-32335 | Dep.(mc) |
| **DLCS–** | | |
| 3050123 | 17-33306 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| **DMIC-Memo–** | **(Non-AEC)** | |
| 63 | 17-32207 | For revision see DMIC-Memo-167 |
| 167 | 17-32207 | |
| **DP–** | | |
| 700 | 17-32190 | Dep.; $3.50(OTS) |
| 818 | 17-32191 | Dep.; $0.50(OTS) |
| 839 | 17-32192 | Dep.; $0.50(OTS) |
| **DPSPU–** | | |
| 62-30-26 | 17-32516 | Dep.(mc); $3.60(fs), $1.28(mf) OTS; Gmelin, AED-CONF-63-018-15 |
| 63-30-5 | 17-31962 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-049-12 |
| 63-30-26B | 17-32284 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-063-5 |
| **DRCL–** | **(Canadian)** | |
| 407 | 17-32158 | Can. J. Chem., 41: 1882-7(1963) |
| **DUBNA REPORTS** | **(Russian)** | |
| See JINR (Russian) | | |
| **DXRL–** | **(New Zealand)** | |
| F8 | 17-32285 | Dep.(mc) |
| **EANDC(E)–** | **(European-American Nuclear Data Committee)** | |
| 45-L | 17-33307 | See EUR-281.e |
| **EFINS–** | **(Misc.)** | |
| 63-29 | 17-32900 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
| 63-32 | 17-32901 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 63-35 | 17-32902 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 63-39 | 17-32903 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 63-40 | 17-32904 | Dep.(mc); $1.10(fs), $0.88(mf) OTS |
| **EUR–** | **(European Atomic Energy Community)** | |
| 40.f | 17-32270 | Bull. Soc. Franc. Minéral. Crist., 83: 295-309(1960) |
| 43.f | 17-32265 | Ann. Musee Roy. Afrique Centrale, Ser. in 8°, Sci. Geol., No. 41, 53p. (1961) |
| 199.f | 17-32269 | Bull. Soc. Belge Géol., Paléontol., Hydrol., 71: No. 2, 1-15(1962) |
| 200.f | 17-32268 | Bull. Soc. Belge Géol., Paléontol., Hydrol., 71: No. 2, 1-13(1962) |
| 213.f | 17-33268 | p. 322-7 of "Third International Analogue Computation Meetings." Brussels, Presses Académiques Européennes, 1962 |
| 229.f | 17-32266 | Ann. Soc. Geol. Belg., Bull. 85: No. 8, 263-308(1962) |
| 254.i | 17-31847 | Rend. Ist. Lombardo Sci. Lettere, B, 96: 157-64(1962) |
| 281.e | 17-33307 | Dep.(mc) |
| 374.e | 17-33365 | Dep.(mc) |
| **EURAEC–** | | |
| 606 | 17-32664 | See GEAP-4197 |
| 637 | 17-32244 | Dep.(mc); $7.60(fs), $2.39(mf) OTS |
| 657 | 17-32404 | See WCAP-2274 |
| 671 | 17-32245 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
| 742 | 17-32241 | See ACNP-63020 |
| 743 | 17-32206 | See ACNP-63021 |
| 751 | 17-32247 | See GEAP-4307 |
| 752 | 17-33311 | See GEAP-4306 |
| 753 | 17-32246 | See GEAP-4251 |
| 754 | 17-32484 | See GEAP-4284 |
| 755 | 17-33240 | See GEAP-4303 |
| 756 | 17-32566 | See ATL-A-137 |
| 759 | 17-33236 | See ACNP-63022 |
| 760 | 17-32660 | See BMI-1638 |
| 765 | 17-32487 | See NCSC-2981-4 |
| 766 | 17-32486 | See NCSC-2663-13 |
| 10027 | 17-32483 | See BMI-X-10027 |
| **EXP-NRX–** | **(Canadian)** | |
| 5707 | 17-32662 | See CRFD-1132 |
| **FRM–** | **(German)** | |
| 42 | 17-32294 | For translation see CEA-tr-A-1221 |
| **FTD-TT–** | **(Non-AEC)** | |

| Report No. | Abstract No. | Availability |
|---|---|---|
| 62-1677 | 17-32541 | OTS |
| **FZM-** | **(Non-AEC)** | |
| 2936 | 17-32988 | See CONF-39-19 |
| **GA-** | **(Misc.)** | |
| 2880 | 17-32570 | Dep.(mc); $4.60(fs), $1.46(mf) OTS |
| 4247 | 17-33308 | Dep.(mc); $3.60(fs), $1.31(mf) OTS |
| 4322 | 17-32837 | See CONF-74-10 |
| 4328 | 17-32974 | Dep.(mc); $3.60(fs), $1.22(mf) OTS; Gmelin, AED-CONF-63-060-34 |
| 4333 | 17-33366 | Dep.(mc); $2.60(fs), $1.04(mf) OTS |
| 4363 | 17-33206 | See CONF-75-2 |
| **GDC-** | **(Non-AEC)** | |
| 63-140 | 17-32208 | |
| **GEAP-** | **(Misc.)** | |
| 3833 | 17-32663 | Dep.; $2.50(OTS) |
| 4197 | 17-32664 | Dep.; $0.75(OTS) |
| 4200 | 17-33309 | Dep.; $1.75(OTS) |
| 4244 | 17-33239 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
| 4251 | 17-32246 | Dep.(mc); $5.60(fs), $1.79(mf) OTS |
| 4277 | 17-33310 | Dep.(mc); $5.60(fs), $1.97(mf) OTS |
| 4282 | 17-32536 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 4284 | 17-32484 | Dep.(mc); $7.60(fs), $2.33(mf) OTS |
| 4303 | 17-33240 | Dep.(mc); $2.60(fs), $1.01(mf) OTS |
| 4306 | 17-33311 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 4307 | 17-32247 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **GEMP-** | | |
| 215 | 17-33312 | Dep.(mc); $11.00(fs), $4.67(mf) OTS |
| **GTR-** | | |
| 17 | 17-32182 | Dep.(mc); $3.60(fs), $1.37(mf) OTS |
| **HW-** | | |
| 69714 | 17-33367 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
| 70711(Rev.) | 17-33368 | Dep.; $0.50(OTS) |
| 71229 | 17-33362 | Dep.(mc); $2.60(fs), $1.07(mf) OTS |
| 74955 | 17-32665 | Dep.; $13.50(fs), $6.02(mf) OTS |
| 75045 | 17-33369 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 76351 | 17-32286 | Dep.(mc); $2.60(fs), $0.89(mf) OTS; Gmelin, AED-CONF-63-049-2 |
| 77935 | 17-32666 | Dep.(mc); $4.60(fs), $1.55(mf) OTS |
| 78131 | 17-33241 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **HW-SA-** | | |
| 2786 | 17-33395 | Dep.(mc); $3.60(fs), $1.25(mf) OTS; Gmelin, AED-CONF-63-045-9 |
| 2878 | 17-31835 | Proc. Soc. Exptl. Biol. Med., 113: 16-17 (1963) |
| 2891(Rev.) | 17-33363 | Dep.(mc); $1.10(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-060-39 |
| 2904 | 17-32537 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2920 | 17-33396 | Dep.(mc); $2.60(fs), $0.89(mf) OTS; Gmelin, AED-CONF-1963-025-15 |
| 2926 | 17-32667 | Dep.(mc); $2.60(fs), $0.83(mf) OTS; Gmelin, AED-CONF-63-061-8 |
| 2927 | 17-32262 | Dep.(mc); $4.60(fs), $1.46(mf) OTS; Gmelin, AED-CONF-63-035-3 |
| 2932 | 17-32399 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2999 | 17-32895 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-060-6 |
| 3098 | 17-33370 | $2.60(fs), $0.89(mf) OTS |
| **HWS-** | | |
| 6242(Rev.5) | 17-32540 | See TID-19161 |
| **IDO-** | | |
| 16871-1 | 17-33371 | Dep.; $2.50(OTS) |
| 19031 | 17-33303 | See CEND-139 |
| 28584(Add.1) | 17-33313 | Dep.(mc); $4.60(fs), $1.46(mf) OTS |
| **IEA-** | **(Non-AEC)** | |
| 59 | 17-32029 | See CONF-115-1 |
| **IFA-SN-** | **(Rumanian)** | |
| 17 | 17-32709 | Dep.(mc) |
| **IFP-** | **(Non-AEC)** | |
| 8463 | 17-33219 | See CONF-24-16 |
| **IS-** | | |
| 603 | 17-32074 | Inorg. Chem., 2: 869-71(1963) |
| 698 | 17-32474 | Dep.(mc); $2.60(fs), $0.98(mf) OTS |
| **ISS-** | **(Italian)** | |
| 63/25 | 17-32336 | Dep.(mc) |
| **JEN-** | **(Spanish)** | |
| 119-DF/I-36 | 17-32153 | Dep.(mc) |
| **JINR-** | **(Russian)** | |
| P-1174 | 17-32196 | For translation see UCRL-Trans-973 |
| **JPRS-** | **(Non-AEC)** | |
| 19626 | 17-31831 | $0.50(OTS) |
| 20282(p.17-26) | 17-31963 | OTS |
| 20469 | 17-31964 | $0.50(OTS) |
| 20511 | 17-32295 | $0.75(OTS) |
| **JüL-** | **(German)** | |
| 106-PC | 17-32078 | J. Catalysis, 1: 432-42(1962) |
| 123-PP | 17-32710 | Dep.(mc) |
| 125-RE | 17-33372 | Dep.(mc) |
| **K-** | | |
| 1577 | 17-32337 | Dep.; $0.50(OTS) |
| **KFK-** | **(German)** | |
| 129 | 17-32400 | Dep.(mc) |
| 143 | 17-31814 | Dep.(mc) |
| 153 | 17-33242 | Dep.(mc) |
| **KFK-tr-** | **(German)** | |
| 130 | 17-32195 | Dep.(mc); $1.10(fs), $0.80(mf) JCL |
| **KOA-** | | |
| 1160 | 17-32468 | See TID-18966 |
| **LA-** | | |
| 2900 | 17-32039 | $4.00(OTS) |
| **LADC-** | | |
| 5567 | 17-32072 | Inorg. Chem., 2: 799-803(1963) |
| 5571 | 17-32740 | Am. Phys. (N. Y.), 23: 38-46(1963) |
| 5618 | 17-31853 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-63-049-7 |
| 5627 | 17-31815 | Dep.(mc); $4.60(fs), $1.52(mf) OTS; Gmelin, AED-CONF-63-049-9 |
| 5668 | 17-32776 | Phys. Rev. Letters, 10: 429-31(1963) |
| 5708 | 17-33178 | Phys. Fluids, 6: 1195-6(1963) |
| 5713 | 17-32310 | See CONF-104-1 |
| 5714 | 17-32311 | See CONF-104-2 |
| **LAL-** | **(French)** | |
| 1072 | 17-32905 | Dep.(mc) |
| **LAMS-** | | |
| 2933 | 17-33314 | Dep.; $0.50(OTS) |

| Report No. | Abstract No. | Availability |
|---|---|---|
| **LF–** | | |
| 9 | 17-32287 | Dep.; $0.50(OTS) |
| **LMF–** | **(Italian)** | |
| 62/113 | 17-32711 | |
| 63/10 | 17-33116 | Dep.(mc) |
| 63/17 | 17-32401 | Dep.(mc) |
| 63/18 | 17-33117 | Dep.(mc) |
| 63/26 | 17-32712 | Dep.(mc) |
| 63/27 | 17-32713 | Dep.(mc) |
| **MAB–** | **(Non-AEC)** | |
| 193-M | 17-32485 | |
| **MATT–** | | |
| 157 | 17-33145 | Dep.(mc); $1.60(fs), $0.80(mf) OTS; Gmelin, AED-CONF-62-251-43 |
| 169 | 17-33146 | Dep.(mc); $2.60(fs), $1.01(mf) OTS; Gmelin, AED-CONF-63-048-53 |
| 175 | 17-33173 | Phys. Fluids, 6: 1139-44(1963) |
| 198 | 17-33147 | Dep.(mc); $2.60(fs), $0.95(mf) OTS; Gmelin, AED-CONF-63-048-63 |
| **ME-TN–** | | |
| 1069-1 | 17-32250 | See TID-19224 |
| **MSAR–** | **(Misc.)** | |
| 63-105 | 17-32571 | Dep.(mc); $3.60(fs), $1.34(mf) OTS |
| **N–** | **(Misc.)** | |
| 63-18652* | 17-33148 | See NASA-TN-D-1875 |
| **NAS-NS–** | **(Misc.)** | |
| 3108 | 17-32154 | Dep.; $0.50(OTS) |
| **NASA-TN–** | **(Misc.)** | |
| D-1875* | 17-33148 | $0.75(OTS) |
| **NBS–** | **(Misc.)** | |
| 7919 | 17-33149 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| **NCSC–** | **(Misc.)** | |
| 2663-13 | 17-32486 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 2981-4 | 17-32487 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **NEVIS–** | **(Misc.)** | |
| 116* | 17-33002 | $5.60(OTS) |
| 117* | 17-33003 | |
| **NMI–** | **(Misc.)** | |
| 2801 | 17-32538 | Dep.(mc); $6.60(fs), $2.24(mf) OTS |
| 2805 | 17-32539 | Dep.(mc); $8.60(fs), $3.20(mf) OTS |
| **NP–** | **(AEC File No. for Non-AEC Reports)** | |
| 12981 | 17-31800 | Dep.(mc); $0.91(BIS); 6s. 6d. (HMSO) |
| 12986 | 17-33004 | |
| 12989 | 17-32338 | |
| 12990 | 17-32906 | |
| 12996 | 17-32714 | $4.60(OTS) as AD-415319 |
| 12998 | 17-33373 | Dep.(mc); $9.10(fs), $3.50(mf) OTS |
| 12999 | 17-33315 | Dep.(mc); $8.10(fs), $2.87(mf) OTS |
| 13003 | 17-32572 | Dep.(mc) |
| 13004 | 17-32720 | Dep.(mc) |
| 13019 | 17-32668 | Dep.(mc) |
| **NR–** | **(Misc.)** | |
| 371-016* | 17-33141 | See AD-410077 |
| **NRC–** | **(Canadian)** | |
| 7441 | 17-32345 | Can. J. Phys., 41: 1385-7(1963) |
| 7452 | 17-32860 | Can. J. Phys., 41: 1332-45(1963) |
| 7453 | 17-32749 | Can. J. Phys., 41: 1287-93(1963) |
| 7456 | 17-32063 | Can. J. Chem., 41: 2118-20(1963) |
| **NSEC–** | | |
| 91 | 17-32288 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
| **NYO–** | | |
| 10258 | 17-32760 | J. Math. Phys. (N. Y.), 4: 1029-36(1963) |
| 10271 | 17-32907 | Dep.(mc); $2.60(fs), $0.86(mf) OTS; Gmelin, AED-CONF-63-048-84 |
| 10423 | 17-32721 | Dep.(mc); $3.60(fs), $1.16(mf) OTS |
| 10429 | 17-33226 | Dep.(mc); $4.60(fs), $1.61(mf) OTS |
| 10431 | 17-33227 | Dep.(mc); $4.60(fs), $1.58(mf) OTS |
| 10552 | 17-32040 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| **ORA–** | **(Misc.)** | |
| 03106-11-T* | 17-32906 | See NP-12990 |
| **ORNL–** | | |
| 3379 | 17-33243 | Dep.; $1.25(OTS) |
| 3413 | 17-32041 | Dep.; $2.60(fs), $0.92(mf) OTS |
| 3445 | 17-33316 | Dep.; $4.50(OTS) |
| 3450 | 17-32669 | Dep.; $2.75(OTS) |
| 3472 | 17-33150 | Dep.; $2.50(OTS) |
| 3473 | 17-33222 | Dep.; $2.00(OTS) |
| **ORNL-TM–** | | |
| 361(Add.) | 17-33244 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 595 | 17-33397 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 605 | 17-33374 | Dep.(mc); $2.60(fs), $0.92(mf) OTS |
| 607 | 17-32573 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 636 | 17-33005 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 637 | 17-32193 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 638 | 17-33375 | Dep.(mc); $3.60(fs), $1.34(mf) OTS |
| 643 | 17-33118 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **ORO–** | | |
| 605 | 17-31816 | Dep.; $2.50(OTS) |
| **OTS–** | **(Misc.)** | |
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| 63-31439* | 17-31964 | For translation see JPRS-20469 |
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| 930,740 | 17-32229 | |
| 930,744 | 17-32391 | |
| 930,746 | 17-32230 | |
| 930,800 | 17-32318 | |
| 930,850 | 17-33287 | |
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| **PNE–** | **(Misc.)** | |
| 202F | 17-31801 | Dep.; $0.75(OTS) |
| 217F | 17-31802 | Dep.; $2.50(OTS) |
| **PR-P–** | **(Canadian)** | |
| 57 | 17-32722 | Dep.; $2.00(AECL) |
| **PWA–** | **(Non-AEC)** | |
| 2184 | 17-32574 | |
| **RCN–** | **(Dutch)** | |
| 16 | 17-32248 | Dep.(mc) |
| **RFP–** | | |
| 307 | 17-32517 | Dep.; $0.50(OTS) |
| **RT-EL–** | **(Italian)** | |
| (63) 3 | 17-32339 | Dep.(mc) |
| **SB–** | **(Non-AEC)** | |
| 62-58 | 17-32482 | Supplemented by AD-408618 |
| 62-67 | 17-32338 | See NP-12989 |
| 63-10 | 17-32533 | See AD-409795 |
| 63-49 | 17-32482 | See AD-408618 |
| **SC–** | **(Misc.)** | |
| 4687(RR) | 17-32728 | Dep.(mc); $1.60(fs), $0.86(mf) OTS |
| 4781(RR) | 17-32209 | Dep.; $2.00(OTS) |
| **SCDC–** | | |
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| **SCPRI(RM)–** | **(French)** | |
| V-1963 | 17-32289 | Dep.(mc) |
| **SCR–** | | |
| 608 | 17-32680 | See TID-17277 |
| 636 | 17-32729 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 641 | 17-32475 | Dep.; $2.50(OTS) |
| **STI-PUB–** | **(International Atomic Energy Agency)** | |
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| **SUI–** | **(Misc.)** | |
| 63-11 | 17-32279 | See CONF-77-3 |
| **SY–** | **(Misc.)** | |
| 5455-R | 17-32249 | Dep.(mc); $10.10(fs), $4.07(mf) OTS |
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| 7668 | 17-32908 | Dep.(mc); Free (Massachusetts Inst. of Tech.) |
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| 18966 | 17-32468 | Dep.(mc); $9.10(fs), $3.35(mf) OTS |
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| 19066 | 17-33328 | Dep.(mc); $3.60(fs), $1.28(mf) OTS |
| 19067 | 17-31854 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 19068 | 17-32194 | Dep.(mc); $5.60(fs), $1.82(mf) OTS |
| 19111 | 17-32290 | Dep.(mc); $8.60(fs), $2.66(mf) OTS |
| 19112 | 17-32402 | Dep.(mc); $2.60(fs), $0.98(mf) OTS |
| 19116 | 17-32730 | Dep.(mc); $3.60(fs), $1.25(mf) OTS |
| 19122 | 17-31817 | Dep.(mc); $14.50(fs), $6.53(mf) OTS |
| 19123 | 17-32042 | Dep.(mc); $7.60(fs), $2.48(mf) OTS |
| 19124 | 17-32043 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 19126 | 17-31855 | Dep.(mc); $8.60(fs), $2.99(mf) OTS |
| 19127 | 17-31830 | Dep.(mc); $5.60(fs), $1.94(mf) OTS |
| 19137 | 17-32731 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 19161 | 17-32540 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 19166 | 17-31856 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 19168 | 17-31818 | $1.60(fs), $0.80(mf) OTS |
| 19169 | 17-32732 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 19170 | 17-32340 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 19173 | 17-31819 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 19175 | 17-32341 | Dep.(mc); $3.60(fs), $1.16(mf) OTS |
| 19179 | 17-31986 | Dep.(mc); $8.10(fs), $2.90(mf) OTS |
| 19181 | 17-32575 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 19183 | 17-32044 | Dep.(mc); $2.60(fs), $0.89(mf) OTS |
| 19184 | 17-32045 | Dep.(mc); $6.60(fs), $2.12(mf) OTS |
| 19185 | 17-32046 | $4.60(fs), $1.49(mf) OTS |
| 19198 | 17-32047 | Dep.(mc); $10.10(fs), $3.92(mf) OTS |
| 19203 | 17-32155 | Dep.(mc); $14.00(fs), $6.38(mf) OTS |
| 19213 | 17-32048 | Dep.(mc); $2.60(fs), $0.95(mf) OTS |
| 19224 | 17-32250 | Dep.(mc); $10.10(fs), $3.92(mf) OTS |

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| 7224(Rev. II) | 17-31803 | Dep.(mc); $3.60(fs), $1.22(mf) OTS |
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| 7357 | 17-32734 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 7408 | 17-33119 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
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| 10855 | 17-32342 | Dep.; $1.25(OTS) |
| 10866 | 17-33120 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 10867 | 17-33121 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 10868 | 17-33122 | Dep.(mc); $2.60(fs), $0.83(mf) OTS |
| 10874 | 17-32343 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 10882 | 17-31981 | Dep.(mc); $2.60(fs), $1.10(mf) OTS |
| 10897 | 17-32918 | Dep.(mc); $3.60(fs), $1.16(mf) OTS |
| 10927 | 17-32476 | Dep.(mc); $1.10(fs), $0.80(mf) OTS |
| 13084 | 17-32846 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **UCRL-Trans–** | | |
| 953(L) | 17-32542 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| 972 | 17-33223 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| 973 | 17-32196 | Dep.(mc); $1.60(fs), $0.80(mf) JCL |
| 978 | 17-33009 | Dep.(mc); $4.60(fs), $1.55(mf) JCL |
| 981 | 17-32735 | Dep.(mc); $2.60(fs), $0.89(mf) JCL |
| **UR–** | | |
| 629 | 17-32292 | Dep.; $0.50(OTS) |
| 630 | 17-31820 | Dep.; $1.00(OTS) |
| **VDIT–** | **(Swedish)** | |
| 77 | 17-32049 | Dep.(mc) |
| **WAPD-T–** | | |
| 1579 | 17-32919 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| 1582 | 17-33245 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **WCAP–** | **(Misc.)** | |
| 2274 | 17-32404 | Dep.(mc); $1.60(fs), $0.80(mf) OTS |
| **WT–** | **(Misc.)** | |
| 1462 | 17-31804 | Dep.; $1.50(OTS) |
| **Y–** | | |
| 1272 | 17-32293 | Dep.; $3.50(OTS) |
| 1417 | 17-32518 | Dep.; $2.00(OTS) |
| 1420 | 17-32477 | Dep.; $0.75(OTS) |
| **ZFK-PHA–** | **(German)** | |
| 8 | 17-33008 | Dep.(mc) |
| **ZFK-RN–** | **(German)** | |
| 19 | 17-32405 | Dep.(mc) |
| **ZFK-WF–** | **(German)** | |
| 21 | 17-32670 | Dep.(mc) |
| 22 | 17-32671 | Dep.(mc) |